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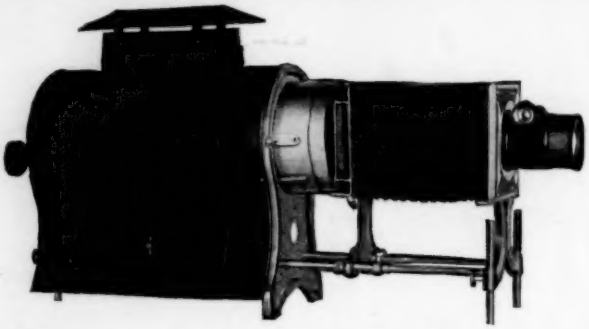

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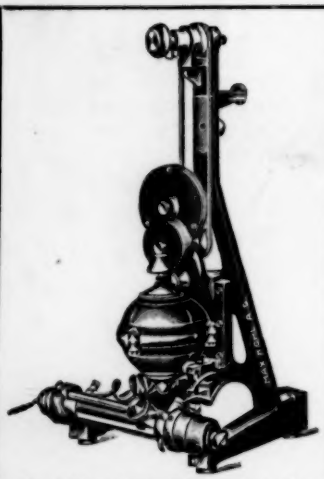

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SCHOOL SCIENCE AND MATHEMATICS

VOL. XVI, NO. 4 APRIL, 1916 WHOLE NO. 132

THE CONTENT, METHOD, AND RESULTS OF THE HIGH SCHOOL COURSE IN CHEMISTRY.[1]

BY ALEXANDER SMITH.

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When, some fourteen years ago, I was writing my half of a book on *The Teaching of Chemistry and Physics* (Longmans), and attempting to collect all the important discussions of the subject, I found in the reports of the New York State Science Teachers' Association more valuable suggestions than in all other sources put together. It gives me especial pleasure, therefore, to meet with so many who are members of that Association, and to acknowledge the debt which I owe to their papers, and particularly to the report of the Committee of Nine.

I find that we cannot follow the order of the title, for the *content* may be barren of results if the *method* of using it is not sound, and the methods employed naturally depend upon the *results* which are desired. We begin, therefore, with the results, because they determine the content and the methods.

It is not our aim to begin the training of chemists, although we are proud of such of our pupils as do become chemists. Nor are we preparing our pupils to enter college, for on an average only about five per cent of our graduates enter college, and of these perhaps only twenty-five per cent continue the study of the science there. Our course is thus to a small extent a foundation for more chemistry and to a large extent a part of a general education. It must help the man to sell life insurance or to take part in business as a clerk and work his way into a higher position. It must help the woman to do good office work, to perform household duties intelligently, and to know whether her child

[1]Address before the Science Section of the New York State Teachers' Association at Rochester on November 23, 1915.

has some serious disease or is only imitating some disease while cutting a tooth. It is part of an education for life.

Chemistry Teaching for By-products.

Now, the specific operations of business and of housekeeping are not discussed in the course. Apparently, we must teach three ways of preparing oxygen, five chemical properties of chlorine, six physical properties of hydrogen, and the uses of these substances, in such a way that the process adds to the *general* mental and physical efficiency of the pupil. Evidently, we teach chemistry, in part at least, so as to secure several important *by-products.* After all, the fact that the by-products may be as valuable as the primary product is to the chemist not a new idea. Yet this conclusion reveals the fact that our task is an enormously difficult one. It is easy to take a text and to make the pupils memorize lists of elements, lists of atomic weights, lists of properties, and lists of modes of preparation, but, if the information is simply piled into the memory without plan or connections, it is not a part of a real education. Arranging bricks, according to a plan, so as to produce some useful structure, is one operation, and throwing them into a heap is another and much less useful operation. The methods of extracting the by-products is not shown very conspicuously in the books—the handling of almost any book could be done mechanically and fruitlessly. Not the topics, but the way of handling them, will determine their value. The chemistry must be made largely a means, and not entirely an end in itself.

Live Chemistry.

Now, clearly, chemistry that is to yield valuable by-products must be *alive*—not dead. Let us assume that *live chemistry* is the desired result, and try to define the term suitably. The term seems to be used in different senses. Varnish and photography could be taught so as to be as dead and useless to the young pupil as indium or europium. It is not a question of live subjects; the subjects are not themselves alive, but the method of handling them must be so. Live chemistry must mean chemistry learned so that the pupil is interested in it and becomes more intelligent during the process. This is the result we are striving for. It must be chemistry, or it is not what we are discussing. It must be alive, or it is not education. It must therefore be both.

For our purpose, the analogy of the living plant is suggestive.

The living plant is recognized by four characteristics. It is *rooted in the ground,* and its roots and root hairs permeate every part of the soil. They also draw water, with dissolved food (potash, combined nitrogen, etc.), from it. It *spreads its stem and leaves in the air,* and takes in nourishment (carbon dioxide) through these organs. It *grows,* and so demonstrates its successful connection with the soil and air. It is *useful,* as food if a vegetable, or for ornament if a flowering plant, or for shelter and lumber if a tree. Pull up the plant and it dies. It dies because the connections with the soil and air have been destroyed.

The Chemistry Plant.

Is not live chemistry like a plant? It must be rooted in the pupil's head. That is, to live, it must be intimately related to the previous knowledge and habits of thought of the pupil. It is useless to plant the chemistry away from all the elements of the pupil's previous education and previous acquirements—just as useless as to plant a vegetable two feet above the ground, if we expect it to live. This suggests the idea that a soil analysis of the pupil's brain might be useful to one who intends to plant something new in it. It suggests also that we must select those parts of chemistry which can be related to the previous knowledge, the powers, and the interests of the pupil.

The spreading of the leaves corresponds to the mental and physical environment of the pupil. In Gary he will be interested in steel and metallurgy, in other places in photography or agriculture. In all surroundings he is familiar with many articles and processes which have intimate connections with chemistry. The girl is familiar with cleansing and with materials and processes used in the house. Discussions of the applications of chemistry will thus contribute to the intellectual nourishment of the pupil.

Again, the chemistry, like the plant, must grow. Merely memorized chemistry will lie largely unaltered in the mind. We must not plant bare chemical results, any more than we would plant full-grown cabbages. We must plant ideas, and we must establish connections between them and the previous knowledge (the soil) on the one hand, and the practical applications (environment) on the other.

Finally, the chemistry plant must be useful. Amongst plants, it resembles the legumes (clover, alfalfa, etc.) more than any other family. The chemistry crop must be of value in itself, but,

more than this, it is our hope that it will fertilize the soil and enable this to produce still better crops of other kinds later. We must improve the pupil's habits of thought, and give him, if possible, tendencies to correct observation and reasoning, mental flexibility, and initiative.

A Soil Analysis.

Clearly, the soil, that is, the previous knowledge, experience, and mental habits of the pupil, must be studied and analyzed. We soon discover that there are two kinds: the kind we imagined occupied the pupil's head, and the kind that is actually there. For example, we know that the pupil has had all the rules of arithmetic, and we assume that he will readily apply them in chemistry. Often the pupil has had physics, so we assume that it will not be necessary to teach him anything about that science, and we expect that he will apply his knowledge wherever possible. We assume that he has some practical knowledge, and will not try to boil water in a thick-walled glass bottle. When we find he has successfully set up an apparatus to generate hydrogen, but on closer inspection discover that he has used glass rods throughout, instead of tubing, we become more awake to the actual situation. The pupil has had so much training in language work, and especially in English, that we expect him to use words with discrimination, and to describe his observations with precision. But he calls a bead "clear," when he means colorless, forgetting that it might be clear and also blue (like the clear blue sea) at the same time. Finally, we discover that, to secure clarification of his rambling statements, we must teach him the technical vocabulary of chemistry as if it were a lesson in a language, and demonstrate to him anew that clear expression is necessary to clear thinking.

But there have been still other farmers working in the same soil before our turn came. Did the teachers of mathematics, Latin, French, and history put into the soil anything that we can use? In studying a foreign language, we meet a new word, and the dictionary gives three English equivalents, often all more or less obsolete words. We obtain only a hazy notion of the meaning. But we meet the same foreign word again and again, in new connections, and each time we gain a clearer idea of its usual meaning. We compare the cases, we make hypotheses in regard to the meaning, and we adjust each hypothesis until we reach certain knowledge. Thus, by repeated observation and comparison, and by the construction of hypotheses, we ascertain

the facts. Is not this the scientific method? Perhaps we assume that the use of this common-sense method is natural. In reality, however, it is an acquired habit. Do we believe that the supposed cure for the plague, by hanging a spider in a bag round a man's neck, was ascertained by trying different animals until the spider was selected, and different species of spiders until the one that effected a cure was discovered? On the contrary, we know that a striking, perhaps, repulsive notion will be accepted by the average human being, without any evidence, much more readily than a well-studied, but less exciting statement. The scientific habit of mind has to be acquired by constant self-restraint, and constant practice.

Some think that the study of a language is mere memory work. But many words have several different meanings, and observation and reasoning must be employed in ascertaining the meaning in any given case. Take the word hold. We can hold (own) stock. We can hold (arrange) a meeting. A vessel can hold (contain) water. We can hold (maintain) a course. One can hold one's tongue, where hold means to withhold, or one can hold a conversation, where it means just the opposite. One can hold (judge) another man to be a fool, and one can hold forth on the teaching of chemistry. In languages, things which are equal to the same thing are not equal to one another, and the use of the scientific method in finding the true meaning in a given case is indispensable. Then, too, there are generalizations or laws in languages. Like natural laws, each states some general fact, and is called a rule of grammar. In language work, experiments are frowned upon, but the other features of the scientific method are in continual use. We may assume, therefore, that the pupil has learned the scientific method, and that he can and will apply it. All this is the analysis of the soil as we imagine it.

Sometimes we go further. Professor Hall tells of a teacher of physics who placed a block of wood before each pupil, and expected each to draw a conclusion. After an interval of severe strain, the visitor asked the teacher what conclusion he expected them to draw. "Why," he said, "the conclusion that matter will not set itself in motion of its own accord." The pupils were expected to invent the conception of inertia!

While enumerating the constituents of the pupil's previous knowledge, such as arithmetic, physics, and the scientific method, we realize that they must form an excellent soil for the growth of live chemistry. But, after some experience as teachers, we

discover, also, that connections with these valuable elements are not made spontaneously by the pupil. Unless we assist the pupil in making the connections, the fertile materials might as well not be there. Shall we decide that we have no time to make the connections; that we are there to instill a lot of chemistry, and have no concern with whether it lives after being planted? What should we think of a farmer who said, "I am here to dig potatoes and sell them, not to spend months in planting and hoeing"; or, "I wish to cut corn, or to pick cotton, and sell it, not to labor over the raising of a crop"? We should know in advance that he was bound to fail.

New Applications of Arithmetic Hard to Make.

The pupil has had arithmetic, but he has applied it to apples and bricks and ditches. A new application, to chemistry, is confusing. The human mind works in ruts far more than we realize. Tell a man the uses of the various levers employed in running an auto, and he will believe he could run it. But let him try, and he will discover his mistake. He opens the throttle when he intended to throw out the clutch, and before long he does three wrong things all at once and stalls the engine. After an hour's practice, he is thoroughly exhausted in mind and body. Yet he had to do no one thing that required effort, or was in itself very novel. It was the new combination of purposes and motions that floored him. If I were to give you a problem in chemical arithmetic, you would find it easy. You would perhaps think you were reasoning it all out from abstract principles. In point of fact, however, being familiar with that sort of problem, you would have from the start a general view of the stages in the operation and of the result to be expected, which would be of great assistance. For the rest, you would follow routine methods acquired by habit, and of genuine, pure reasoning there would be very little. Let me rather give you a proposition in arithmetic applied to zoology. In this connection you, as teachers of chemistry, have no preformed, semi-blind habits, and you have to depend on reasoning. Also, you cannot focus the answer itself more or less clearly before the working begins. The problem will, therefore, be more like a chemical problem set before a novice in that science. The proposition is that, if there are more cows in the world than there are hairs in any cow's tail, then there must be at least two cows in the world with the same number of hairs in their tails! A chemist cannot even grasp the

proposition, much less recognize its truth. He cannot recall whether it stated that there were more hairs or more tails, or more cows in the world. Suppose the proposition had been: If there are more atoms in the world than there are different atomic weights, then there must be at least two atoms with the same atomic weight. Any teacher of chemistry can see that to be true. He thinks he has verified its truth by reasoning. In point of fact, however, he knows in advance that there are innumerable atoms of each of the ninety kinds, so he can accept the conclusion without having to reason it out at all. The pupil has not this advantage, and so stumbles pitifully. Even after this chemical parallel, the chemist cannot see through the cow problem. Zoological arithmetic requires reasoning, of a chemist, and none of us reason until compelled to do so.

Being teachers, however, we know where the trouble lies. A general statement is always apt to be confusing, so we skillfully substitute simple, concrete numbers for the *x*'s and *y*'s it contains. Suppose there are only *four* cows. Now, "there are more cows in the world than there are hairs in any cow's tail." That permits the hairiest cow to have three hairs in its tail. The second has two hairs. The third has one hair. The fourth cow *must,* therefore, repeat one of these numbers. Hence, if there are more cows in the world than there are hairs in any cow's tail, there must be at least two cows with the same number of hairs in their tails!

If the fourth happened to be a Mexican, hairless cow, the proposition would have to be restated, so as to cover that possibility. To restate it will place serious mental strain on a chemist —although a zoologist can do it without effort.

The teacher needs to realize afresh every year how difficult and confusing a subject, old to him, but new to his pupils, can be. Perhaps if he were to spend a part of every summer, learning to play some simple musical instrument, he might begin the year with a more vivid recollection of the number of blunders an intelligent person can make in doing something demanding a little thought and the acquirement of new habits. We expect of our pupils a mental and physical alertness and adaptability which we are far from possessing ourselves.

Applying the Scientific Method.

Our pupils have been using the scientific method, but they are not masters of its use. How few investigators, even, can use it

outside the limited range to which they are accustomed. Cavendish, as a chemist, was unusually able. But, when his housekeeper asked him what he wanted for dinner, he used the scientific method, and finally said, "A leg of lamb." He never noticed that every time the question was asked, he always reached (by reasoning?) the same conclusion. When two eminent Frenchmen were coming to dinner, the housekeeper ventured to hint that something more than usual would be desirable. Rigid and prolonged application of the scientific method led finally to the reply: "Yes, let us have two legs of lamb." Yet, his reasoning about the gases in the atmosphere was admirable, and, if the spectroscope had been known in his time, he would have advanced the date of the discovery of argon by a hundred years.

The pupil's use of the scientific method in language study was entirely unconscious. How, then, can we expect him consciously to apply it to chemistry? It is there, in his mental soil. But, like the potash in feldspar, it is in chemical combination with other things, and has either to be set free with the help of the teacher, or be introduced in the form of a fresh supply, before it becomes available to the chemistry plant. In one college physical laboratory, the directions for an experiment were to take a gauge and measure the diameter of a wire in several places. The instructor assumed that the pupil had learned the value of repetition in previous studies, and knew why it was of value. But one pupil came up and said: "I have measured the diameter of the wire in all the four corners of the room. Where shall I measure it next?" The same pupil had probably met the word *cum* hundreds of times. But, instead of realizing that this repetition was responsible for his very precise knowledge of its meaning, he simply thought that it was an unusually nice word, because, after five or six encounters, he was no longer compelled to look it up in the dictionary.

Then, too, while fact, and hypothesis, and law are used in language work, they are not so named in that connection, and their identity when again encountered in chemistry is not recognized. Still, again, the phenomena of the language are in print, and all the pupils are observing the very same phenomena. Counting and classifying the appendages of the cockroach is not very difficult, if every pupil is supplied with a specimen. But when, as in chemistry, each pupil has to create for himself the phenomena to be observed, it is no wonder that variations arise and that reasoning from different data leads to divergent conclu-

sions. Chemistry is like language study, only it is much more difficult, and we must not expect our pupils to be geniuses. The most minute subdivision of the steps in reasoning and the most sympathetic assistance are required, if any rational elements are to enter into the process of learning chemistry.

In view of the difficulties connected with the use of the scientific method, is it worth while to try to bring it to the notice of our pupils? Assuredly it is. How does the successful business man proceed? He gathers all the information he can. He analyzes the apparent facts and classifies them. He finds some which are not facts, some which are only half-facts, some which go far beyond the facts (exaggerations), and some which, although true, are side issues and present a distorted view of the situation. Finally, he ascertains the exact nature of the problem, and proceeds to devise means to meet it. The scientific method is here called business-sense. Like the same method in languages, its use is largely unconscious. But, in its absence, failure, or subordination and mediocrity are certain to be the results. The physician in his diagnosis, and the lawyer in trying to convince a judge or jury, use the same method. Our hope is that, after using the method in languages, chemistry, biology, and other studies, the pupil may acquire some slight tendency to use the method, after graduation, on the problems of life. We expect nothing wonderful, but we hope for some result of this nature. If only we can produce a little awakening, so that the value of rational methods dawns on the pupil, we may be sure that later the fierce interest in his business and the keen competition of others will urge him along the right track and enable him to develop himself into a useful and successful citizen. Is not this a by-product from the course in chemistry which is worth striving for? It may be our particular privilege to strike the spark, where other teachers have tried and failed, and so, to change the metaphor, to inoculate the pupil with the germ, which will later determine his development as a leader rather than an underling. Surely, chemistry taught with a view to such results must be live chemistry.

Applications Essential to Live Chemistry.

Besides being rooted, a living plant must be in intimate, extensive contact with the air. Just so, the course in living chemistry must be not only in close relation with the mental soil, but it must also be in contact with surrounding chemical phenomena

and materials. Relations with applications of chemistry are essential. The atmosphere of everyday life is full of possible contacts with chemistry, and all the teacher has to do is to make the connections. The essential thing, however, is that the applications must be connected with the chemistry in a *vital* fashion, if the plant is to be alive. Some applications may be worth memorizing, if they cannot be connected intimately with the elementary aspects of the science. But numerous applications which are exclusively or largely of this kind are necessarily dead. They resemble placing a plant in a vacuum, and offering it a brick, when it requires carbon dioxide as food. Aluminum silicate is a perfectly good chemical substance, but it cannot be related through the leaves to the life of the plant. As one reads the lists of "live topics" that have recently been suggested, one feels that memorizing must be contemplated, for effecting explicit and vital contact between them and the elements of chemistry is beyond the powers of the great majority of teachers. Tests for adulterants in oils and honey can easily be used, mechanically, but can they all be explained and used to give life to the chemistry in the time available—or at all? Clay and its products are important, but there are acid salts much simpler in composition and easier to utilize as educational material. Cement and glass are of immense importance, but is the laboratory equipped for the optical and physico-chemical study of cement and its reactions? New stunts in photography somehow suggest an appeal to the emotions, rather than to the mind as a rational organ. The applications are a valuable supplement to the more systematic chemistry, but should not play the part of a substitute for it. Such a substitution would kill the chemistry.

A recent, suggested examination syllabus of applied chemistry contains nothing about lead excepting "Lead pipe and shot. Lead poisoning." Lead pipe is a question of engineering. Lead poisoning is a biochemical item of profound difficulty, if it is to be handled so as to bring out the instructive details. Further on we find "Household disinfectants; hydrogen peroxide, hypochlorites, carbolic acid, mercuric chloride, formaldehyde." No mode of preparation, chemical reaction, or property of any of the substances is called for, and therefore the examiner would not dare to set a question demanding an answer on these points. Is it proposed to have the pupils prepare media, cultivate pathogenic bacteria, and observe the behavior of organisms in presence of these disinfectants? Microscopes and sterilizing apparatus

would be required, and there would be serious danger of infections and illness. This kind of live chemistry might kill some of the pupils. Apparently it is merely a question of memorizing the words, for nothing else that is practicable is called for.[2]

Applications suitable for live chemistry must be related to the previous knowledge of the pupil, and to his surroundings. They must not be related solely to his curiosity. As a rule, they must be selected so as to be capable of experimental relation to the elements of the science. It is not sufficient that they attract the attention of the pupil. They must explicitly require utilization of this attention for educational purposes. It is a question—as in the case of a plant—of *relating* the chemistry to the environment and *vice versa*. The items suggested are often such as, with nine teachers out of ten, could only be placed, unrelated, into the memory of the pupil, there to be found undigested and unused, as an inert deposit, at some later date.

The Content.

So much has been said, indirectly, about the content, that little need be added; almost any of the current selections will serve the purpose, provided it deals with chemistry, and provided it affords the possibility of intimate relations with previous knowledge and with familiar phenomena and applications.

The Method.

In striving for the desired results, success depends entirely on the methods used. We have time for a single illustration only. In live chemistry, is it necessary to pay attention to physics? Many texts suggest an answer in the negative. In their introductions they labor to distinguish between chemistry and physics, and leave the impression that, when the distinction has been formulated, the physics will be identified wherever found and will be eliminated. Let us analyze the situation in practical chemistry. How is chemical change brought about? Some people say, by chemical means. One recent author says that mere mixing does not produce chemical change, as if mixing solutions did

[2]Disinfecting power is not a chemical property, although often given as if it were. Hydrogen peroxide kills by oxidizing and so do hypochlorites, but formaldehyde is a reducing agent. The chemical property in the first two cases is that the substance is an oxidizing agent. The disinfecting is an *application* of this property. Again, bleaching powder is often given as a chemical property of hypochlorous acid. But the chemical properties are, that hypochlorous acid is an oxidizing agent; sodium hyposulphite, a reducing agent (bleaches indigo in the dye vat); and sodium hydroxide, a base (bleaches blue prints). Each of these substances can be used for bleaching, but the bleaching is an application of one of the chemical properties named, and is not itself a chemical property. Chemical properties must be stated so as to indicate some type of chemical reaction.

not produce chemical actions in hundreds of cases, and as if mixing suitable substances with chlorine was not almost always sufficient to start the reactions. Rubbing salt in a mortar is a physical operation, but tapping fulminating mercury and tickling iodide of nitrogen with a feather are apparently chemical means! Boiling water is physical, but boiling liquid nitrogen trioxide is chemical. Precipitation is due to physical immiscibility, and is physical. Heating increases the speed of motion of the molecules and is a physical, and indeed, literally, a mechanical means of producing chemical change. Even electrolysis consists in shooting a steam of electrons at the solution, and is now mechanical. All the means we use are physical.

Again, heating a platinum wire is a physical phenomenon. When we decompose mercuric oxide by heating, what sort of a phenomenon is it? A phenomenon is something seen, or more generally, something perceived by the senses. We collect the gas given off and we see the mercury accumulating on the wall of the tube. Certainly the *phenomena* are physical here, also. We even reason physically, for the mercury cannot come from nothing, so we conclude that it is condensing from an invisible vapor. During the process the mass of the oxide becomes less and less. All that we can perceive by the senses is physical.

A certain group of these physical phenomena is not only physical but also chemical. The subgroup is easily defined when the time comes. If one substance gives two, or two give one, or two give two, all the substances concerned being different, then the phenomenon, in addition to being a physical, is also a chemical change. Or, if the composition of a material is such that the elements are present in proportions that can be represented by multiples of the atomic weights by whole numbers, then it is a chemical compound (*e. g.*, a hydrate). If the proportions are not of this nature (*e. g.*, a solution), then it is a physical aggregate.

Thus, we use physical means to produce chemical change, because they are the only means available. We study the resulting physical phenomena, to learn what the change was, because they are the only phenomena. We reason in physical terms about the phenomenon, in order to understand and to classify it, because physical data are the only data available. Finally we draw the conclusion that it was a chemical change, altering certain substances into certain other substances.

Many teachers of chemistry do not realize how far physics dominates the experimental work in chemistry. On distributing

standard texts to the members of a class made up largely of teachers of chemistry, and asking them to report as to certain specific features of the text assigned to each, I have frequently instructed them to consider whether the physics required in practical chemistry was adequately represented. The almost invariable report was, "Yes, Boyles' and Charles' laws are in the book!" Suppose we were rigidly to exclude all physics, including physical properties and phenomena, from the course in chemistry, what would happen? We could not describe common salt, because the solid state, whiteness, and cubical crystalline form would be lacking.

It is evident that a very specific and ready knowledge of many parts of physics will be acquired in connection with a course in live chemistry. The physics need not be called physics, nor need it be forced, for it comes in quite naturally. What physical property of oxygen enables us to utilize the oxygen we draw into our lungs? Evidently, its solubility in the moisture on the inner surface of the lungs. When we burn phosphorus in oxygen, the pentoxide forms an immense cloud of particles and nothing remains in the spoon. But when we burn iron wire in oxygen, no such smoke is formed, and the oxide remains in globules. Why this difference? In classes of freshmen in college, all of whom have admission credit in chemistry, I have never received a sensible answer to this question. The question is asked, of course, to show them that, even from experiments they have nearly all seen before, there may still be something of an obvious nature that they had never considered. The few who venture a reply say that the pentoxide must be lighter than air—an explanation disproved by the fact that the substance in a bottle on the table is in the bottom of the bottle.

Is this real chemistry? The problems of the chemical industries seldom concern the chemical reaction itself. The difficulties almost all arise because of the physical properties of the crude materials and of the products. In the contact process for sulphuric acid, the difficulty did not lie in the reaction, which had long been known, but in the poisoning of the catalyst by foreign substances transported mechanically by the gases. Again, a novice would expect the sulphur trioxide to dissolve easily in water, but it was found that the excess of oxygen used in the process carried a large part of the oxide right through the water and out of the absorbing units. Investigation showed that ninety-seven to ninety-eight per cent sulphuric acid absorbed it much

more completely, and so the acid itself is employed for the purpose.

Is this good education? Well, it teaches closer observation, whenever the real facts are wanted. It substitutes simple reasoning for memorizing. It teaches the need of alertness, and penalizes superficiality. It calls attention to facts, rather than words, as the subject of study. It is not physical chemistry, which is a theoretical subject, but practical chemistry. It would seem therefore that we should give attention to the physical means used to produce chemical changes, that we should show how a chemical change must be explored by physical means, and how it must be described in physical terms. Professor Cooley once said, "An experiment is a question put to nature, and forethought and care are required in putting the question, and study and reflection in interpreting the answer." We may add to this that a chemical experiment is a question put by physical means and the reply comes in the form of physical phenomena. The physical language is the only one that practical chemistry can understand or speak. Physics is the language of live chemistry and without attention to the physics, chemistry is both deaf and dumb.

Conclusion.

Live chemistry must utilize the arithmetic, English, physics, scientific method, and other previous acquisitions of the pupil. It must include vital connections with the chemistry of nature and of the industries. This will be real chemistry if the pupil continues the subject, and real education if he does not. The method must emphasize facts and relations, rather than words. As containing a new subject matter, the course exercises the pupil in applying standard methods to new problems, with the possibility that he may learn later to use the same methods in business and in life, and so become a rational and successful citizen. The basis is in the book, but the connections and how to make them depend upon the laboratory work and the teacher. Live chemistry is the kind taught by a live teacher and so, after all, the results depend entirely upon the knowledge, skill and alertness of the teacher.

BIOLOGY IN HIGH SCHOOLS FROM THE ADMINISTRATIVE POINT OF VIEW.[1]

By John G. Coulter.

This matter resolves itself into a number of questions, foremost of which is the question of the extent to which biological studies shall enter into the subject matter common to all high school students. In other words, how much plant and animal study shall be required of all? Though this is the primary question, it usually lies in the mind of the principal in another form. With him, under present conditions of subject pressure, it is usually a question, not of how much, but of how little of any fundamental subject will do for his general program.

So I think it expedient for teachers of biology to accept the question on the same terms, to recognize the subject pressures which force administrators to minima rather than to optima in determining their common subject elements, and to discuss with them, not so much what biology it may seem desirable for students to know, as what biology to deny them is a sort of educational fraud. Even in such minimal terms, we shall find much to do; much need there is for agreement as to our minima, as well as of effort to insure their inclusion in the common-to-all part of the program.

There are, of course, plenty of good botany and zoology courses. But these courses are largely elective. The large majority of our high school graduates have not had them, or have had plant studies, without animal studies, or animal studies without plant studies. I have found in a number of important high schools that the percentage of graduates, having had no biology at all, except the legal requirement for human physiology, runs as high as eighty-five, and it is quite common for it to run well above fifty. And, unless we accept the biological content of elementary agriculture, or of one-year or half-year general science, as an adequate minimum, this percentage of biological negligence is rising rather than falling. Recently it has been brought out in connection with studies of Illinois high schools, that schools under two hundred in enrollment commonly require plant and animal studies in the second year. The limited number of courses offered necessitates greater uniformity of individual programs, and nearly all graduates get three years of natural science. But in schools beyond two hundred in enroll-

[1]Read before the Biology Section of the Central Association of Science and Mathematics Teachers at Chicago, November 26, 1915.

ment, having an increased differentiation of program, a very different condition obtains. The second year of science becomes elective, with the consequence that usually more than half of the pupils are deflected from it. It is in such schools that large majorities of seniors are found that have had no biological work the program.

* * * * *

Twenty years ago, at the time of the Report of the Committee of Ten (1893), the principle of specialization, rather than of generalization, in science was widely accepted. That is to say, if only one or if even two years were to be allowed for natural science, it was held preferable to devote such time to intensive study of special science rather than to a general study of natural science as a whole. Thus we note in the proceedings of the Subcommittee on Biology that the only point involving important debate was the point as to whether one year only of biology had better be a year of botany or a year of zoology. The decision was in favor of botany (see page 139 of the *Report*). Evidently there was a feeling that biology would generally get only one year of attention, but apparently there was *no feeling at all* that in this year plant and animal studies should both have place. Attention at that time was directed to method, rather than to content. It was common to hear opinion of the worthlessness of less than a full year of attention to any special science. The leaders of that day did what they could to circumscribe scope, whenever scope seemed by its largeness to threaten method; to threaten such thoroughness as they deemed essential to grasp of the principles of science. Quite evidently they felt that science courses could not be science unless they insured this end. The question of a wider range of subject matter, of sacrifice of method for the sake of more mere information, simply did not arise. An elementary general course would have been more simple to construct two decades ago than now, but apparently no one thought of constructing it. It was foreign to the spirit of science, and to what was held to be its mission in education.

How the times have changed this matter! Half way between then and now, general biology came on the stage, a breaker of the barriers between plant and animal studies, and now we have general science, the whole scheme of science, planned for one- or even half-year courses, a breaker of all barriers whatsoever. Surely the pendulum has swung to the other extreme. Is it not time to seek a balance of the claims of the extremists; a middle

course of practice; the middle way that always proves in such a situation the best way out? Almost it goes without saying that the great science teachers were not *all* wrong in their insistence upon such method as shall insure grasp of principles that are the foundation of science, its most illuminating facts. Nor is the present insistence upon wider information all wrong. The older plans might have been well enough, had it been possible to secure continuous attention to the study of natural science throughout a four-year course. Short of that, however, their plans were sure to prove inadequate, for they involved the general omission by individual students of certain groups of subject matter which are simply non-omissible from any satisfactory scheme of secondary education.

So this is a very urgent question that confronts us now. What are these non-omissibles? And how can we include them in a general elementary course without sacrifice of the fundamental structure of science—its organization on the basis of principles? In how brief a course can we do this and do it successfully?

Let us take a specific instance. Take the case of animals. Partly due to the recommendations of the Committee of Ten, partly to other causes, of which the emphasis upon agriculture is one, animal studies have fallen into rather low place as compared to plant studies. That is to say, measured by student hours, there is much more of high school botany than there is of high school zoology. Yet how indefensible is any plan that contemplates exclusion of animal studies from the work of any student, whatever his course may be! Though yet undetermined, there is, of course, a least common denominator of attention to animal studies, just as there is a least common denominator of attention to plant studies. It is our task to determine the nature of that denominator, and to insure its inclusion in all courses. That is to say (I venture it as a principle which should need no defense before this audience) there is a certain amount of fundamental knowledge about plants and animals lacking which any scheme of secondary education is sure to prove unsatisfactory, and the individual upon which such a scheme of secondary education has been imposed has been to that extent defrauded of his educational rights.

High school administration, having granted us this principle, and it does now, as it has in the past, quite generally grant us this principle, at once asks us to be more specific. "How much time do you want?" the principals say. "We can't give you much.

Take just as little as you can, for if your plan calls for more than we can allow, we shall have to reject the whole of it." Thus confronted, we witness a division of opinion among ourselves. There are those who are disposed to take what tradition allows, making faint argument, if any, for larger place, and seek, I suppose, to make the best of it—if any best *can* be made of one year only for science. For we all recognize, I think, that the science that is common to all in high school courses is, quite generally speaking, only one year of work. To be sure there is commonly a second year, but that second year is usually in the form of an obligatory option between a number of subjects, and so does not concern a discussion which limits itself to the elements common to all.

Now can we, in a one-year course, teach what should be the common elements of science in secondary education (plants, animals, man and all the rest), and teach them as they should be taught, on an organized rather than on a disorganized basis? Though none of us may possess perfectly clear vision as to what these common elements should be, I think we do very largely possess a strong consciousness that the thing can't be done decently in a year.

Look into the one-year general science texts and consider carefully their treatment of organisms. Is it either adequate or accurate? Can we rest at all content with the biological content of these books as expressive of the biological constant in secondary education? "But," some say, "there is to be a year of biology following the year of general science." Yes, but if we make this year *elective,* it ceases to be a constant, and usually more pupils are deflected from it than pass through it. If, on the other hand, it be *required,* then why not eliminate the biological content of your first science course, get your seasonal adjustments right (plants in spring semester, animals in fall), and plan the whole two years with a view to the two years as a whole?

"But," say the passivists, "we can't get the two years, so it's a waste of time to talk about them. Let us keep on experimenting (is it *real* experimenting?) with the one-year plan, and presently something may come of it." The truth is that we have been experimenting with the one-year plan for a quarter of a century, and nothing really satisfactory has come of it, and it is perfectly predictable that nothing really satisfactory will come of it. Almost every combination of subject matter has been tried, and found more or less wanting. The demands for scope of sub-

ject matter, and the demands for its organization, are both imperative in this situation, and *both* can't be satisfied in a year of work. Who says we can't have two? The principals? I'm not so sure. Indeed, I venture the statement that the impediments to the two-year plan lie quite as much among the science teachers themselves as in the opposition of administrators. I have rarely talked with a principal about this matter whose opposition to the two-year plan did not lie mainly in the contention that science teachers themselves have come to no manner of agreement as to what should be the nature of such a general elementary course. In this very city that principal who more than any other has had to do with shaping the science courses states that the chief obstacle to a two-year course is the lack of concurrence among the science teachers with reference to it; that if they would agree on a plan and give it united support he believes that the administrative difficulties could be readily overcome.

Surely we have been moving too much along the line of least resistance. From every quarter we hear of increase of recognition of the two great content subjects—natural science and social science. But what have we done to prepare for this greater recognition? What are we ready to agree upon as desirable, now that our place on the program is about to be enlarged? The other subjects, all of them, are tools of the interpretation or of the expression of experience. But in natural science and social science (including history), we deal with the stuff of experience itself. The nine-year unit constants of the Committee of Ten were English 3, foreign language 2, mathematics 2, social science 1, natural science 1. Does this arrangement express current thought as to relative values? Most certainly not. But two-ninths of the constants were assigned to natural and social science in 1893. Today at least twice that place is allowed them in theory, if not in practice. But why not in practice? Precisely because we have done so little to perfect our pedagogy in terms of the larger place that is ready for us when we are ready to take it. We have seen false virtues in makeshifts while we should have been lifting our eyes to the larger place, that is, the legitimate place of our subject, and making plans for such synthesis of our materials as will effectively fit the new situation.

Who can defend, on professional grounds, the merits of a one-year general elementary course as compared with the merits of a two-year general elementary course? Yet we find that thing undertaken. That a briefer course has a tremendous advantage

over a longer one in courting administrative favor goes without saying; other things being equal, administration will always prefer the shorter course. The principal turns for guidance to the expert. If one expert holds out for a two-year plan, while another in whom he has equal confidence encourages him to think that one year is quite the thing for general elementary science, of course he is going to take the one that gives him more time for other things. Besides, general science offers to do the thing not only in one year; it offers to do it with one book. Much claim is made of the popularity of one-year general science as proof of its merit. We have just been listening to statistics indicating the growth of this plan. We submit, however, that such growth is proof of expediency rather than proof of merit. The rapid spread of a contagious disease is surely no proof of its virtues. Facts are facts, to be sure, but without thorough-going interpretation, they get us nowhere.

* * * * *

The tendency to make eighth grade work departmental, the junior high school movement, gives an opportunity to reorganize the science work that we have not had before. If we start the work in the eighth, general elementary science can hardly be held back from a two-year place even by the hands of its friends. Principals themselves have taken the initiative in this direction. The recent report of the Program of Studies Committee of the Illinois High School Conference contains the following significant sentences:

"The committee believes that the organization of a course in elementary science covering two years would be of large value in the solution of the science problem in the public schools."

"* * As a two-year course, it will permit a certain amount of organization in the sequence of topics, while, at the same time, it will afford ample opportunity for approaching every topic from the point of view of the pupil's needs, interests, and experiences."

"* * The committee suggests as a tentative proposal that the course proceed from simple inorganic phenomena to the more complex phenomena of organisms, culminating in the study of man. This sequence is roughly indicated by the terms, *physical environment, plants, animals,* and *man.* A marked advantage of this procedure is that it preserves a continuity with the natural science materials that have been standardized under the general term, geography, in the elementary curriculum."

Inevitably it is geography that lends us our starting point. It is that large part of geography that is non-political that furnishes us in grades four to seven what we may call *the first instructional cycle in the materials of natural science.* Now in grade eight or nine we are to begin the second. Here we are to plan that course—I do not hesitate to say a two-year course—that is, to provide for the large majority of our pupils all they will ever

have of definite training in nature, and in the intimate relations and applications of her principles and processes of life; all that the large majority will ever have of study of life and environment in terms of science.

What then shall this course be? Long since the boundaries of special science have been burst in this connection. The demand for a *general* course is imperative. No one or two single branches of science will serve. Other content will not be denied. No course will stand that excludes any of the truly great facts of nature.

Just as purely organized science has proved itself too limited in content, similarly, general science under the one-year plan is proving itself too deficient in organization. By this I mean, of course, general science that attempts to be general in content and scientific in organization, and to be both in one year of 150 hours! This can't be done. With the fundamental aims of general science one may be quite in accord. I am. Yet one may surely protest against attempt to fulfill those aims under impossible conditions. General history *as a one-year course* was hopefully and thoroughly tried and found unsatisfactory. A similar discovery is being made as to general science.

But let us say what our course shall be as well as what it should not be. Let us bring our case into court. It is *not* a case of botany vs. physics, or of biology vs. physiography, or of the claims of any special science whatsoever. The names of the special sciences are names better left out of this discussion than included. Their inclusion fogs the real issue. Our real issue, our real cause is, of course, the pupil and the pupil's needs, his needs as to this great realm of natural science, and no special science has claim here for its own sake. Its claims rest wholly on the extent to which it contributes to a unified result determined by a conception of the pupil's needs. Glimpses of this, of that, and of the other science will never do. We must have a *natural* unit of natural science made in the image of the pupil in his or her world; not in the image of the scientist in his laboratory. This is what general science is *trying* to do, of course, and failing to do when through too brief time it denies the pupil his chance to build up, gradually and enduringly, logical organization of his knowledge; an organization that he needs just as much as the scientist in his laboratory.

So now we have our case in court. The pupil. He has been there before. But a trouble has been that he has not been kept

in his proper place. To much for his own good we have sought for wisdom in him rather than in ourselves. He has been more than the case. He has been judge and jury too. We have catered too much to his alleged interests. Yet what in the world is more fluctuating and vagrant than the *unguided interests* of youth!

To find out what interests the pupil is no more important than to find out what, in the pupil's interest, should be omitted or postponed. There is widespread belief that the pupil's interest depends on method more than it does on matter, but there is little belief, if any, that method can make a real science course out of a jumble of subject matter. Science means "a way of solving problems," but it equally means more than that. In that sense alone, good nature study is science, and nature study is for the lower grades. But soon the organization of subject matter has important claim, a claim equal, if not prior, to that of method. The high school beginner is more ready to appreciate and apply science as organization than science as method. So the teacher needs a vision to see why this attractive topic or that needs at this time or that, in its own interest, a certain restraint of treatment. The course as a whole, like a picture, should have its parts in true perspective. We perceive in this connection the great need that exists for determination of the relative values of subject matter in the field of elementary science. Its mass looms greater, and its order for elementary pedagogical purposes is less, than any other of our great divisions of subject matter.

But to go back to the pupil as he stands on the threshold of what we call his secondary education. He is fresh from that great glimpse that geography has given of the physical world in which he lives. He is ready to go on from that point. He *needs* to go on from that point. In science *as science* he is, of course, not interested—not usually; that is, if you ask him. But in life and what fashions it, he is more interested than in anything else. He is still wondering what sort of world he is in, and has a hunger that he may not show for what will interpret and explain the experiences that crowd upon him; for what will light up the future that he vaguely feels with secret apprehension. His place in the world—that's what he wants to know. He wants a scheme of things, one founded in the familiar facts about him, one that interprets and makes things clear, one whose truth is attested in every experience, rather than one that is in a book and apart from daily life. This hunger of his we know he

has because we felt it keenly ourselves; felt it even more keenly at his age than we feel it now, though to have given tongue to it was quite beyond us. The boy that still lives in us is better evidence of what boys want than a hundred experiments. Why experiment with him as we might with a creature of another order when he and we were one only the other day? There is much of false conception in the outcry against "authority" in education, and in the cry for "experiments" that so easily may not be real experiments. The "authority" of a wise teacher may be more scientific than a hundred experiments, each with their hundred sources of error.

So it is life and its controls, its laws and its inescapable conditions, its fundamental needs and its wonderful possibilities that we will interpret for him in his two-year general course in natural science. Gradually, painstakingly, we will have him paint the picture. First, the background. The great primitive and permanent controls of life. Heat and light, matter and motion, gravitation, air, water, and soil, the dynamics of topography, inorganic and then organic, and their relationships; these we shall interpret through many a familiar instance, through study of media and of experiences that are matters of every day and all the time.

This setting of the stage for life—through the fall term. Then, in true genetic order, plants and their relations to soil and water and light and air, and their great role in the life of men. This in the spring term, the most fortunate seasonal adjustment; an environmental study. Fall, again, in the second year, for animals, when insects abound—in September, best month of all for the approach to animal studies. Now we are getting in the foreground of our picture—life.

We come finally to its central figure—man. Man in the last term of this four-term course. His modern adjustments made in keeping with fulfillment of the ancient and continuing primal needs of his body. The body, product of a long and different past now appreciated, its limitations recognized, to be controlled and managed that it may work effectively like some fine instrument, despite the artificial conditions that civilization imposes upon it. Physical environment, plants, animals, man—do you get a glimpse of the picture that such a basis of the course suggests? Look in the last *High School Manual* and you will get a suggestion of the same picture in its indication of "physiography, botany, zoology, and physiology" as the desirable two-year

sequence of the science courses. The difficulty with those terms is that they do not sufficiently suggest the synthesis of the whole, but rather the old "water-tight compartments" to which we all object. It is synthesis that we need—effective pedagogical synthesis, and determination of relative values in terms of pupils' needs, future as well as immediate, perhaps future *rather* than immediate. It is effective foundation that we want first, rather than unstable though attractive superstructure.

Whether the sort of picture of elementary science I have suggested appeals to you or not, some sort of picture you will have to get. Until you do have some such picture in mind, you will find yourself at loss in determining what you yourself want the general content of your science courses to be. Until you do get such a picture, science will seem to you only a mass of facts to be picked from, and all this claim for the greater value of principles will be only a murmur in your ears. Until you yourself possess a vision of the unity of nature, all the eloquence in the world may not persuade you of the value of plans to create such a vision in the minds of youth. You will continue to think of this fact and that in terms of the facts themselves rather than in terms of their relative significances.

ANIMALS AND PLANTS WHICH LIVE IN BRINES AND RAW SALT.

Just west of Promontory Point station, Utah, is a pond cut off from the Great Salt Lake by the railroad embankment. At times of high water in the lake this reservoir fills by percolation through the embankment, but during the summer this water is concentrated to a brine by evaporation. The deep pink color of the brine is a phenomenon that appears in salt ponds generally when a certain concentration is reached. In the salt ponds of San Francisco Bay this color is due to a certain bacillus which lives in saturated brines and also in the heaps of salt as it is piled for drainage and shipment. Prohibitive to life as such an environment might be considered, strong natural brines are, in fact, inhabited by a number of minute organisms—animals as well as plants. The pink color disappears in winter or when fresh water is introduced into the pond. The Southern Pacific Company has done some experimental work on preserving piles and railroad ties by soaking them in the pond.—*Overland Guidebook, U. S. Geological Survey.*

SCIENCE INSTRUCTION.

By Barnard S. Bronson,
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In the present state of society and education, science, properly I believe, occupies a considerable portion of our attention and our time. Whether or not science has secured its proper allotment of time in the curriculum of our educational institutions is an open question. This problem by its very nature seems to preclude the possibility of final solution.

This is as it should be. We can, at the best, hope only for a fair adjustment of time for the moment until the needs of the morrow show us that the old is inadequate. There are many who are willing to assume prophetic roles and to show us the follies of following blindly the traditions of the past. To some of these we owe our progress, to others we owe our most disastrous ventures and excursions into the untried and the unknown. All honor, however, to the young men who see visions and to the old men who dream dreams. God hath chosen the things which are not, to bring to naught the things that are. The vision must precede the reality.

In the attempt to solve the problem of the place of science in education, each one of us at present engaged in science instruction occupies a place probably considerably larger than he dreams. Incidentally, however, this position may not be the position of his dreams, but the influence of each is widely extensive. With us, consciously or unconsciously, rests its solution.

Anxious as we are, all of us, to advance those intrusted to us for the best interests of the future, can we say truthfully that the time spent with us has been utilized for the best interests of society? Is it not possible that had that time been spent elsewhere in the pursuit of other branches of knowledge, society at large would be the gainer?

This is the question that society puts to us and from us it demands an accounting of our time and the time of our pupils. Inasmuch as the individual receives ordinarily the major part of his education from its hands, it follows that society is well within its rights in making such a demand upon us, its servants. To a certain extent, latterly, we have freed ourselves from the bondage that originally obtained, that of the slave that literally led the child, the first pedagogue, dependent upon the largess of the individual and his will, but we are none the less the servants

of society at large; by society we are released from certain obligations that are imposed on others. Our mission is to serve, the highest privilege that society may accord to any of its members. We must then with our privileges accept our obligations and we cannot in justice resent the accounting demanded.

In what way does science instruction minister to society's needs? Life consists in the continuous adjustment of the individual to its environment, spiritual and physical. Education seeks to point the way to the end that disastrous collisions of the individual and his world may be less frequent. Education seeks to provide the lubrication that will minimize attrition and its consequent loss.

Nature is relentless and inexorable in her elimination of the unfit. To exist even comfortably, for a time, one must remove himself from this class. "Natura non agit per saltum." In the process of elimination, nature does not advance by cataclysms. Ample warning is given to each. The saddest condition in life is the later realization of a warning unheeded. "The mills of God grind slowly but they grind exceeding small."

"To him who in the love of nature holds communion with her
visible forms
She speaks a various language."

Nature speaks. To hear, the listening ear must be attuned accurately to receive and without error to record her messages.

"This our life * * * finds tongues in trees, books in the running brooks, sermons in stones and good in everything."

The aims of science instruction, as I view them, are twofold, the acquisition of a certain amount of desirable information and the development of a certain scientific habit of thought. Neither of these may be subordinated nor neglected without distinct loss to the individual.

Our first thought in science instruction is the acquisition of data. Our most serious mistake, as instructors, I believe, lies in the fact that too frequently this is our Omega as well as our Alpha. We regard our task as completed, our duty well performed, when our pupils have succeeded in acquiring this data. If, in recitation, our pupils are able to repeat, possibly after us, more likely than not in our own words, some particularly

delightful or interesting bit of information, our responsibility ceases and we claim the reward of work well done.

It is with a feeling of a considerable degree of guilt; or at least chagrin, that I find too frequently my own words, phrases and sentences returned to me in oral recitation or upon written examination papers exactly as they were given. These expressions, never having been digested nor assimilated by the pupil, are returned unchanged by any mental process in his mind. As ordinarily my thoughts are not the pupil's thoughts, as the thoughts of one individual can never express exactly the mind of another, so the pupil's words, as expressive of his mind, should not be the exact reproduction of my own. Such statements ordinarily we mark as correct and, quite properly, in the matter of fact. However, they indicate more truly a failure on the part of the pupil from the viewpoint of education.

If we were concerned most especially with our subject matter, this might suffice, but we are not; we are concerned most especially with the minds and mental attitudes of our pupils. It is our business to teach *our pupils* primarily; this must be accomplished through and by means of our subjects. These are our tools, with these we must work. How often we hear the expression, "I teach biology, chemistry, physics, mathematics," or some other particular branch or, most unfortunately, possibly all of them, or others, and how often we must realize that such a response to an inquiry, though conveying properly the information sought, only too literally defines our occupations. We do teach biology, chemistry, physics, or mathematics, etc., and what are our finished products? Just what we teach, so much photosynthesis, chemical equilibrium, harmonic motion, maxima and minima. We measure our successes or our failures in terms of the perfection of our instruments. It is much as if in visiting a cabinetmaker's shop to see the evidence of his handiwork, he should respond to our inquiries by stating he had a splendidly sharpened chisel or a finely articulating and adjusted lathe. These are necessary for his craft, but it is not in this that our interest lies, unless by chance we, too, are cabinetmakers. What are *our* finished products?

I believe our emphasis is too largely misplaced; we are expending too much time and energy on the perfection of our instruments. In another connection, entirely, but as truly applicable here, I believe, Matthew Arnold has said, "Faith in machinery is our besetting danger, often in machinery most

absurdly disproportioned to the end which this machinery, if it is to do any good at all, is to serve; but always in machinery as if it had a value in and for itself * * * He who works for machinery * * * works for confusion."

In all forms of instruction our data or our informational side is important, it must not be minimized, but it must be made the *agent,* not the end. To be of any value to the individual or to society at large, our data must be in available form. Our second great aim in our instruction lies in thus making our data or our knowledge available. This involves the mental processes that we usually call the thought processes or the processes of thought production. Prof. Gumplowicz, in his *Outlines of Sociology,* however, states: "The great error of individualistic psychology is the supposition that man thinks. The whole belief in the freedom of human action is rooted in the idea that man's conduct is the fruit of his thoughts, and that his thoughts are exclusively his own. This is an error. He is not self-made mentally, any more than he is physically. His mind and thoughts are the products of his social medium or the social element whence he arose and in which he lives." However we may term these educative processes, our knowledge, our data, to be made available must be wrought upon to become truly the possession of our pupils and of society. Availability to the pupil depends upon his arrangement of the data; it is in this respect that he needs our assistance. The specimens and pictures in our mental museums must not be "skied," we must have them at hand where we may reach them conveniently. We do not thus increase our information, but we do increase its utility and thus our usefulness in service and so make our general contribution to the welfare of society. "Reasoning adds no more to our body of knowledge than the arrangement of specimens in a museum adds to their number." However, as in our libraries, we are warned constantly against misplacing the volumes by the sign, "A book misplaced is a book lost," so in our mental libraries, a fact misplaced is a fact lost.

We have sufficient knowledge at hand to revolutionize the world. President Van Hise, of the University of Wisconsin, said comparatively recently: "There have been more advances in knowledge in the past sixty years than there were in the two thousand years before that time. In a large measure, this knowledge is unknown to the people. We know enough about agriculture so that the agricultural wealth of the country could be

doubled if the knowledge were applied. We know enough about eugenics so that if the knowledge were applied to men, the defective processes would disappear in a generation. We know enough about disease so that if that knowledge were utilized, infectious and contagious diseases would be destroyed in the United States, and that within a score of years. Similarly, in other fields, our knowledge has gone far beyond the utilization of the people." As teachers it is our business to discover these facts, this information, to the people. As the servants of society, our aim should be the increased usefulness of its present and its potential members. As instructors in science, I believe we are particularly fortunate in having so definite a place in society. There is no lack in the clarity of call that comes to each of us.

In a considerable measure, I fear the criticism that has been visited upon our work and that of our schools in general is merited. This is not due to low ideals nor to a lack of endeavor on our part to meet society's needs, but it is due rather to errors in the determination of our bearings. Our courses are not properly charted. Society has asked us to educate its future members and we have responded by giving them what we call subject matter that too largely is inutile, hence the social criticism of our work.

Our modern civilization differs from the ancient in its scientific aspect; it is doubtful if our appreciation of art or literature is so far superior to that of some of the eras that have preceded our own. There is no doubt, however, that we are immeasurably superior to all in science. Our work in the schoolroom must take its direction from the needs of the present age.

Naturally, in science instruction, at least theoretically, we conform rather more closely to this spirit. In the study of art and literature, though not expressed so boldly, the veiled aim seems to be conformity; in science, the open aim is, or primarily ought to be, the Truth, the Eternal, the Unchanging, without regard to conformity or nonconformity. In this, the best or the highest will not suffer.

In life from his earliest years, the pupil has been engaged in acquiring facts and in endeavoring to fit these into his system of life. He is confronted daily with phenomena and crises unknown to him previously and upon these he must act and upon his decisions he must succeed or fail. In the schoolroom, the pupil has been concerned too largely with the thoughts of another. Leaving his own thoughts, he must learn from a text

what another has thought and to this he must conform. From another he must endeavor to guide his actions and to derive his judgments. Is it any wonder that the child fails? No other has lived his life, no other knows his life, his mental content, but another must decide for him. As teachers, we are considerably at fault in this respect because of our insistence upon the authority of the text, or upon our own authority. The child is taught to disregard his own opinions, to subordinate them to, or at least to subscribe to, those of his superiors to such an extent that it has been charged that we as a people are in danger of mental atrophy through the disuse of our mental capacities. That the child and the inferior should be guided is axiomatic. The spiritual, the mental and the physical welfare of such demand that he must know and must respect, in so far as is possible, the "best that has been thought or known." To this extent we must recognize authority, but it is the insistence upon the lesser authority that, carried to its extreme, develops the inferior mind, one that must know another's thought before it may dare to formulate its own. How frequently we must recognize this in the classroom when in recitation we receive at first from the pupil only a meaningless jargon of words expressive of nothing. The pupil has endeavored to recall the authority, has succeeded but imperfectly and has not dared to substitute his own thought, with the result that we receive this jumble expressive of neither the authority nor the respondent.

To such instruction, too largely a goodly part of our secondary and, may I say, also our higher education tends. The province of science, I believe, is, in so far as possible, to counteract and to repress this tendency. Science abjures authority, in its realm it is sufficient unto itself. For another's opinion as stated in the text, we properly confront the pupil with the phenomena itself and ask him to formulate his judgment concerning it. His first introduction to the subject matter or content of his course is the reality itself and from this he proceeds to the expression of it. It is in this that our science instruction differs from most other forms. It is this converse method of presentation that involves the student in so much difficulty in his first courses in science. He is unaccustomed to this method in the schoolroom. His tendency is to perform his laboratory work in a more or less perfunctory way and to consult his text, or authority, again, before he ventures to give an expression to his opinion of it. In this he is too often aided and abetted by his instructor for the

purpose of gaining time and covering the required ground. Why should the pupil not avail himself of the information at hand? Carried farther, since our elementary class is not the place for research, why should the pupil do any laboratory work at all? All has been done before, all is known. If when the pupil thus meets with difficulties he is allowed to substitute for his own thought or expression that of the teacher or that of the text, he, in so far as this substitution takes place, nullifies the whole spirit of science and thus is allowed to deprive himself of that for which all our science stands. Why should the pupil concern himself with the action of heat upon potassium chlorate alone and then with the action of heat upon potassium chlorate and manganese dioxid, only later to turn to his text and discover from that that the latter action is catalytic? If this is his method, can we properly justify the time spent in ascertaining this fact so accessible to him? Granted that the experiment is desirable, is not the whole purpose that the pupil should thus discover this fact for himself? He then possesses the fact and also makes himself the master of the method by which he ascertained it. In this particular instance, I believe pretty much of the whole value of that experiment lies in the latter, the method.

Our instruction in the laboratory and in the classroom should be directed less to the inquiry of "what" than to the inquiry of "why." The latter presupposes the former, where too frequently the instruction of the pupil entirely ceases. In our newer forms of instruction, we are directed to turn our instruction away from those things that heretofore largely have occupied our attention and to direct them into more "practical" channels. It is desirable probably that we should do this, that we should, for instance, teach by "project" whatever this may come to mean.

By such "practical" instruction the pupil probably may gain something, but if the method of instruction remains the same, both the pupil and the instructor may find that they have been lured over the stile into Bypath Meadow, and they will sooner or later be confronted by Doubting Castle and its grim occupant, Giant Despair.

It matters much less what we teach than how we teach it. A remark attributed to one of our most eminent chemists is that, the best course in science he ever pursued was first-year Greek. Here, evidently, the value derived consisted not in the content, but in the method of the course. By the introduction of laboratory work into our courses, this method is to a certain extent

realized. The word "introduction" is used here with a full realization of its import. The pity of it is that it is also recognized largely by our pupils. With an acumen, not often attributed to them, they recognize too frequently the futility or the inutility of this part of our work and give it the attention that it properly merits.

Relation of the work in the laboratory to the realities is most highly desirable for the purpose of dispelling the listlessness or perfunctoriness of our pupils. They should be made to see that the work possesses more than an academic or purely scientific value. The interest of the pupil ought to be considered on its merits in the selection of our laboratory work, but it should not be made the sole guide. The danger lies here in that we are likely to o'erleap ourselves and fall on the other side. The exercises should be selected because of their general relation to the entire course, that they may serve as a means of mental development and that they may illustrate certain desirable principles or phenomena. If at the same time we can interest the pupil, well and good, the pupil is the gainer in that the normal resistance to the educative process is by this interest so much lessened.

By making this interest, however, the criterion of desirability, the pupil then becomes the judge of the value of the work; this, needless to say, is improper because of his inexperience and his general incompetence to assign to the various exercises their true values. The interest motive is a powerful ally of the instructor and should not be disregarded. Whenever possible, the exercises should present to the pupil a real problem, the purpose of which is not, however, the possession of the fact that presents itself in its solution, though possibly we may allow the pupil to regard it in this light. The true purpose is to develop the capacity of the student by making him observant of small differences; by causing him to find definite relations in phenomena apparently widely diverse; by making him assign to the varying conditions their relative values; and, finally, he must be led by his own processes of method and thought to a correct and unbiased expression of the observed phenomena or its causes.

In the classroom, our concern is mainly the same but our method should be somewhat different. What are we to do for the pupil as he thus meets us? Our great function is to teach the pupil how to live. When we consider the complex activities of life, how may we live best with the greater part

unknown to us? We may live only by noting small differences and likenesses and predicating of the unknown what we have observed of the known. In other words, our greatest aim in science is generalization. The details must, in greater part, remain unknown always to the most of us, but upon this we must proceed, nevertheless, to formulate our judgments. In our first steps our methods must be inductive. In our life, in our application of these principles, our method is deductive, but induction always precedes deduction. By this continuous method of presentation in the classroom, we must bring the student to an understanding of these relations. The first method we must employ in the establishment of our principles and the second in our application of them to life. Here it is most largely that we must connect our subject and our laboratory work that has ordinarily preceded it to the world's realities and to the life of the pupil particularly.

Inductively, the laws of Boyle and of Charles grow readily out of the experiences of the pupils, and should come to them only as a more definite statement or restatement of well-known conditions frequently observed by them. By rather definite questions, Avogardro's hypothesis follows very closely upon this presentation, and, by the presentation of facts in their proper order, the student is quite ready to venture as his own explanation of the observed phenomena that the solution *may* lie in the fact that "equal volumes of gases * * * contain the same number of particles or molecules." For such presentation the teacher must bide his time until he has accumulated a number of facts that demand explanation, and must awaken in the mind of the pupil a desire to know why such phenomena occur. He has then overcome in a large measure the necessity of trying to impress upon his pupils the reality of his subject. The reality exists and is recognized by the pupil before it is presented formally. Our classroom work should deal largely with the "why," in so far as this can be presented. Comparatively early, before our course is half completed, we should rise to the heights of our subject, in that the pupils should become acquainted with our greatest generalizations, and they must be taught to watch for these and to recognize them, if possible, however obscurely they present themselves.

One great aim must be recognized, in addition to those above named, definiteness and accuracy of expression. Dr. John H. Finley, in a recent address, stated that he found

in untruthfulness three underlying causes—first, ignorance of the fact; second, a deliberate misrepresentation of a known fact; and, third, an inability to state a known fact through the inadequacy of expression. With all of these conditions the instructor must deal. The best interests of society demand of us that we inculcate in those with whom we come in contact the truth, that society itself may benefit by its more extensive promulgation. It is not enough that we inculcate alone the desire for truth. By this alone society would advantage; we must disclose the truth as we see it and we must prepare others that their vision may be more keen to extend our horizon and our ken more widely and they must be prepared to give expression accurately to their brightest visions. To a certain extent, we minister to this aim in our demand for laboratory reports accurately and carefully presented. In the classroom it is again more particularly our province to demand accuracy of interpretation, possibly first, but first only because of necessity, that is, first in point of time, but not in importance, then accuracy in the expression. This expression must be the expression of the pupil, not of another, not the expression of the text, nor of the authority, but of the fact. It is our business to see that the pupil is confronted with the fact or phenomena first and then is able to proceed to an accurate and complete expression of it.

If we can to a certain degree increase the capabilities of our pupils along these lines, I believe we need have no fear of the accounting demanded of us by society. They then will join with us and will ask that the allotment of time to science may be increased and that its hands may be lifted up and sustained until the going down of the sun.

GEOGRAPHY AS A PREPARATION FOR CITIZENSHIP.[1]

By R. H. Whitbeck,
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The subject matter of geography is so all-inclusive that the study may be shaped to almost any purpose. Physical geography, for example, when taught with much field work, may be made an instrument of *scientific training*. Selected human aspects of geography may be emphasized, and the study made a means to *general culture*. The economic aspects may be emphasized, and the study be made a *training for commercial life*. Again, the subject matter may be so selected and the emphasis so placed that geography serves as a direct *training for citizenship*. The aim of this paper is to ask not only "May geography be an instrument of training for citizenship?"—but, "Ought geography teachers consciously to make this a dominant aim?" Is there a more worthy purpose which geography can naturally serve than helping to prepare young people for enlightened citizenship?

For a long time, geographers have agreed that geography ought to be humanized, ought to make students intelligent regarding the industries, resources, commercial advantages and governmental activities of their own country. The recommendations of the N. E. A. Committee of 1909 on the Improvement of High School Geography, say:

> "This study should show the distribution of our resources, their accessibility, their relation to road building, to distribution of population, to development of industries, to location and growth of cities, to commerce, and to social conditions. The work of our government in modifying geographic environment should receive careful consideration. Our government is expending vast sums of money in carrying on soil surveys, in improving plants and animals, in reclaiming desert and swamp lands, in the preservation and extension of forests, in developing waterways and harbors. These are subjects upon which every man and woman should be informed from the geographic point of view. The value of such work in molding useful members of society is certainly very great."

Geography for citizenship is not a new idea. Salisbury, Barrows and Tower in the preface to their *Elements of Geography* go on record in these words: "Indeed, the book has been written with the belief that the chief object in geography teaching should be preparation for citizenship."

Nobody who knows these three geographers believes them unmindful of the scientific value of geography, or of its cultural

[1]Read before the Earth Science Section of the Central Association of Science and Mathematics Teachers at Chicago, November 26, 1915.

value, or of its commercial value, and yet they declare that they consider the primary aim to be training for citizenship. If this is true, then geographers must eventually unite in an effort to shape the content of geography, and select its points of emphasis, so that the study shall actively, and purposely, contribute to training for citizenship.

Leadership Calls for Breadth.

There are two types of citizens—the majority, who are content to let others do much of their thinking for them, and who follow leaders; we call these people the masses. The other group is made up of those who are qualified to do their own thinking, and to act as leaders of thought and of opinion. The first group is made up mainly of those whose education is limited. The second group are those who have had larger educational opportunities. The high school and higher schools are the institutions in which leaders of thought must be trained. In the smaller affairs of public life the high school education is sufficient to raise its possessor considerably above the general level of enlightenment. More and more the high school and higher schools must furnish the people who determine public policies, make the laws, and administer public affairs. Preparation for leadership, either in a small way or a large way, must involve at least a degree of *breadth*—breadth of information, breadth of vision, breadth of interest, and breadth of sympathy. Said Mr. Frank A. Vanderlip, organizer of the great $50,000,000 corporation formed (1915) to promote American trade, "It is evident, whether we wish it or not, that we must, as a nation, begin to think internationally." Breadth is always opposed to provincialism. The broad-minded man is one who is competent to see things in their relations to other things; who knows something of history; who knows his own country and people; his own country's resources, its elements of strength and weakness, and moreover, knows a good deal about other countries and peoples. In short, the citizen who may be trusted to lead, is the man who acts in a broad way because he is competent to think in a broad way, and because he is broadly informed in the matters with which communities or states or nations are vitally concerned.

The Geographical Aspect of Certain Public Questions.

Many of the large questions confronting the American people today have a distinctively geographical background. The whole question of conservation is a geographic as well as an economic

question, and it is one of the big problems which confront us. To understand the question of conservation, one must be informed as to the resources of our forests, of our mines, of our soil, our fisheries, our water powers. These are all matters with which geography is concerned. Moreover, we must know the rapidity with which we are consuming these resources, and to what extent we are wasting them. Clearly, all of these are questions with which geography is legitimately concerned.

Again, the great question of the improvement of our waterways will be before the American people for decades. Congress has authorized the beginning of improvements on the Ohio River alone which promise to cost $70,000,000. An extension of this policy to the Mississippi, the Missouri, and other great rivers, involves eventually the expenditure not of millions, but possibly of billions of dollars. Such a prodigiously expensive enterprise should not be authorized by the representatives of the people, excepting as a result of the intelligent conviction that this enormous expenditure is justified. The whole disgraceful "pork barrel" history ought to be known. The American people should know of the shameful waste of public money under the guise of river and harbor improvements. Not that all this money has been wasted, by any means, but that the system is rotten to the core. The nation should not enter upon a waterway improvement if it is going to be a continuation of "pork barrel" methods.

To have even an intelligent opinion upon the improvement of the Mississippi River involves a knowledge of the habits of rivers, the never-ceasing supply of sediment which they carry and deposit, and the enormous difficulty of keeping this sediment dredged from the river channel.

Again, such questions as the building of the Panama Canal, the New York barge canal, the Hennepin Canal and other canals which are perennially proposed, are intimately related to geography. Geography cannot concern itself in a technical way with such matters as coast defense, and yet some knowledge of the character of our coast, and of the relation of the character of the coast to the possibility of landing troops, contributes much to intelligent thinking and voting upon this great question. One would think from the scareheads in our papers and the half-digested articles that are flooding our magazines, that all a foreign army has to do is to sail up to the coast at any point, disembark, land upon the coast and capture the country. One has only to see that, in the present great European war, with Germany's com-

mand of the Baltic and her great advantage over Russia in the campaign of the past summer, she has been unable to land soldiers by water on Russian territory. One can see from the experience of the Allies in the Gallipoli peninsula, that even when the aggressive nation absolutely commands the sea and is fighting a very inferior power like Turkey, the landing of troops and the conquering of even a small strip of coast has been exceedingly costly and up to date impossible. In our campaign in Cuba and Porto Rico in the Spanish-American war, though we had command of the seas, we found it a difficult process to land soldiers in those almost defenseless islands. It should be understood that it is one of the most difficult of military undertakings to land troops on the coast of a hostile country, 3,000 miles or more from their base of supplies, and maintain them there until sufficient numbers have been landed to make the invading force effective. Adequate knowledge of a few phases of this question would dissipate a great deal of the talk about the ease of invading the United States. Not that reasonable preparedness itself is undesirable, but that two-thirds of the dangers which are played up in the press are imaginary. Even in the *harbors* of western South America, ships frequently have to leave port and put out to sea during a storm, to escape being dashed to pieces—this even in a harbor. Would it not be well, in the high school at least, to introduce the student to the geographical aspects of these great national problems?

Geography and Foreign Affairs.

But all our problems are not domestic. We have taken our place in the council of nations. He who aspires to intelligent leadership, even in the smaller affairs of life, ought to be broadly familiar with the countries of the world, their resources and their food-producing ability, the character of their people and of their government, their elements of strength and of weakness, the reasons why they are great, or why they are not, the causes of their rising power or their declining power, and the probable limitations to which they must submit.

When studied and taught from this angle, geography broadens into political-economic geography, and is a big element in the education of the people of a self-governing country. I cannot think of any study which will better fit young men for citizenship than this political-economic study of their own country and of the other countries of the world. Such a study broadens the mind,

broadens the interests, broadens the vision, and it gives a basis for judgment in public affairs. Narrowness is always weakness. The man who knows only his own neighborhood or his own country is necessarily narrow. He is not able to appreciate problems in their larger bearings; he is unable to think in broad terms; he is unable to grasp public policies. It is the man who knows and knows well the facts which the geography of his own country and of the world can teach, who has the elements of enlightened citizenship.

In a recent article in *The Americas*, the new magazine devoted to the expansion of American foreign trade, a writer says: "Obviously Americans in business life who will lead in the future will be men of broader outlook than in the past—men with the 'world view.'" More and more our country and every important country is involved in foreign relations; more and more our domestic affairs are connected with our foreign affairs. This is a reason why geography may be a training for citizenship.

It is not contended that all of these laudable attainments can be acquired in a single half year or year of geography. Only a start toward them is to be expected; yet many a man traces his mode of thought, his views of life, back to some teacher and some branch of study in his school life. The writer of this paper traces some of the most valuable elements in his own education back to a single teacher of his early days, a man who started him into certain habits of thought; certain ways of looking at things; a certain habit of mind. Because geography offers this splendid opportunity of giving young people an intelligent interest in our own national affairs, and in those of other nations of the world, it is a potentially valuable training. If geography has a single dominant purpose to which other purposes are subordinate, I believe training for citizenship is that purpose.

DRILL STRUCK WOOD AT 1,900 FEET.

One of the first deep wells drilled in the West was put down near Huxley, Nev., by the Central Pacific Railway in 1881, in a search for good water. The boring reached a depth of 2,750 feet, but the water obtained was of a very unsatisfactory quality. At 1,700 feet the drill encountered a bed of "petrified clams," and the record states that at 1,900 feet well-preserved "redwood timber" was found.—*Overland Guidebook, U. S. Geological Survey.*

AN EXPERIMENT IN ADDING.

By C. G. Bradford,

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This experiment is essentially mental in nature and has been used by a number of investigators, such as Kraepelin, Woodworth and Wells, and others.

Aim.

The aim in this experiment is to investigate the influence of practice and the influence of secondary factors, that is, physical momentary conditions, fatigue, concentration, and so on.

Method and Means.

Two subjects, the writer and Dr. E. L. Kuhnes, took this test which extended over a period of one hundred and thirty-nine days. Both subjects were men approximately thirty years of age who were doing graduate work in the School of Pedagogy and the Graduate School of New York University.

The writer will be designated by "G" and Dr. Kuhnes will be designated by "K" throughout this series of tests. Subject G took these tests three times per day, Series A, Series B, and Series C. Subject K took them once per day. A complete record was kept for each subject from which tables and graphs were made.

The materials used for this experiment were a sheet of paper containing twenty columns of figures, a common lead pencil, and paper on which to write down the sum of each column of figures. The sheet of paper containing the figures had two sections of ten columns each. Each column contained ten one-place numbers from 2 to 9 inclusive, which were arranged in haphazard order. The numbers in the columns were so arranged as to render the columns as homogeneous as possible in difficulty of adding, and the columns could be added either vertically or horizontally. A sheet like that used is inserted here for reference.

Procedure.

The tests were taken by Subject G three times daily, Series A between seven and eight in the morning, Series B between one and two in the afternoon, and Series C between ten and eleven in the evening. Series A was taken for speed or quantity, Series B was taken for quality or correctness, while Series C was a combination of Series A and B.

There is always the objectionable feature in such experiments when a specific copy is constantly used, of memorizing the copy. In this experiment the subject could soon memorize the sum of each column of figures and thus destroy the possibility of improvement, by further practice, in the mental processes involved.

To prevent this evil as much as possible, the subjects made frequent changes with reference to adding in vertical and in horizontal columns. Other changes were made, such as beginning either at the top or at the bottom of the column, and further variation was used by adding vertical columns in order from right to left or left to right; also in adding horizontal columns the order was varied by adding them in order from top to bottom or from bottom to top. All these changes were made not to vary conditions under which the tests were made but to prevent as far as possible, reducing the experiment to a mere test of memory aided by physical facility or finger movement.

These changes themselves, however, offered an objection which will be explained in the next section of the experiment. At first the adding was not done with much facility or with much confidence of correctness, and the process was number by number as they were reached in the column. But this slow,

7	3	5	8	6	2	9	2	7	5
3	9	8	4	5	8	3	6	5	7
5	2	3	7	8	4	7	8	3	4
8	4	7	3	3	9	5	5	3	4
4	7	4	6	7	6	2	9	8	9
6	3	6	4	5	8	8	4	4	8
4	7	3	2	5	2	4	7	4	7
5	6	5	4	9	5	7	3	6	3
9	9	7	9	7	9	5	5	2	8
2	3	9	5	2	4	6	7	4	3
—	—	—	—	—	—	—	—	—	—
4	7	2	9	5	6	3	8	9	8
7	3	7	3	7	9	8	5	3	4
3	6	3	7	6	4	5	7	7	7
6	4	8	4	8	8	9	4	2	9
5	9	6	5	4	7	4	6	8	3
9	8	4	8	3	3	5	9	4	6
5	6	8	7	4	9	6	9	3	8
8	6	5	5	4	9	8	9	3	4
2	9	4	3	7	6	6	2	5	5
5	7	9	6	5	3	9	4	6	3
—	—	—	—	—	—	—	—	—	—

uncertain process later came to be more rapid and certain. Finally, in many cases the figures were practically unconsciously added by groups, and by easy combinations. For instance, in adding a column in which 3, 4, 3, and 8 came consecutively, the

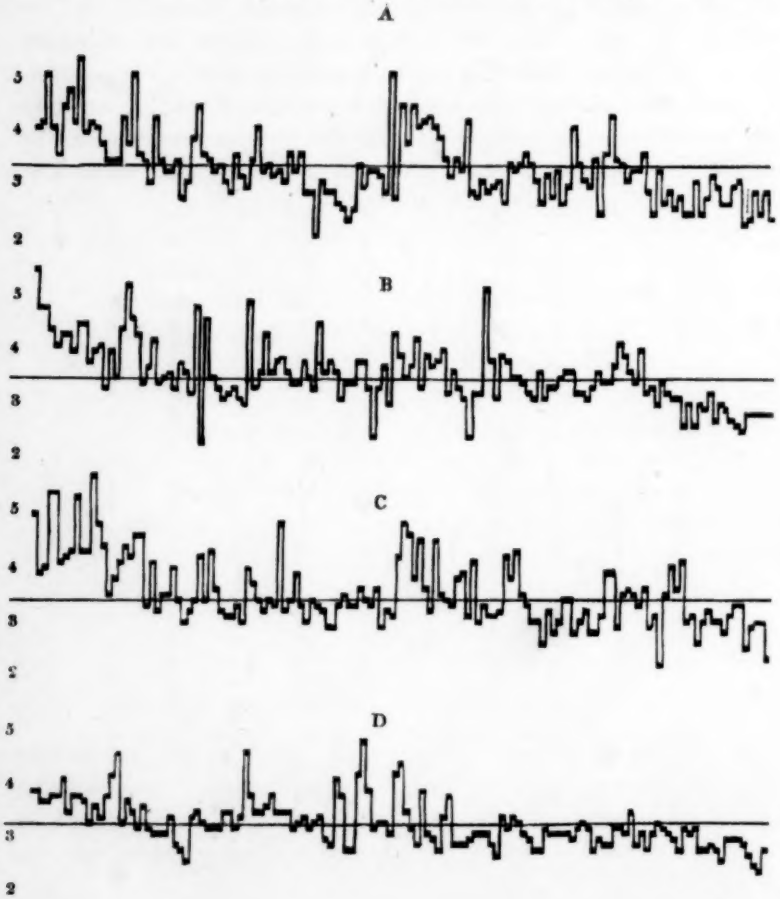
tendency was to take in the group as 18 rather than add the figures one at a time, that is, 7-10-18.

Results.

From the daily records tables have been compiled and are included here for reference and clearness in explaining the daily progress. Curves have been plotted for each of the three daily tests for Subject G and for the one test daily for Subject K. Subject K took the tests at the same time and under the same conditions as Subject G's Series C tests.

Practice curves A, B, and C show the results of tests for Series A, B, and C for Subject G. Practice curve D shows the results of Subject K's tests.

These curves follow the typical practice curve, where there is a constant amount of work, and the time the variable. That is,



they begin with a rather slow rate of time (rather high on the scale) and take a constantly, though much fluctuating descending course, and the time rapidly decreases.

Some of the more noticeable fluctuations are due to the changes in the manner of adding which has been mentioned and described.

When the change was from either an up or a down vertical direction to either a right or left horizontal direction there was always a loss of time, at least for the first two or three trials. But the change when from horizontal to vertical did not cause a retardation, but sometimes caused an increase in efficiency or a gain in time.

It would seem from these results that although reading can be more economically accomplished, by occidental peoples at any rate, when the words are in horizontal formation than when in vertical formation, it does not hold true for adding figures. Because invariably a change to horizontal adding increased the time. This is probably due to the fact that we have always been accustomed to adding in vertical columns and the mind is rather inclined to be inert to an innovation.

By referring to the table we find that the maximum time taken for Subject G to do a test was 5.75 minutes, the minimum was 2.09 minutes; the general averages were, for Series A, 3.38 minutes; for Series B, 3.58 minutes; and for Series C, 3.55 minutes. The maximum for Subject K's tests was 4.75 minutes; the minimum, 2.44 minutes; and his general average was 3.28 minutes.

The records for errors show some very interesting facts. Those for Subject G, Series A, B, and C differ markedly from those for Subject K. They all show considerable variation at the beginning of the experiment, even for forty or fifty days, after which Subject G's records seldom show an error. While in the case of Subject K's record there is little or no improvement in accuracy. Subject G never reached as low an average in time by .10 of a minute as did Subject K, but he practically eliminated error. Whereas Subject K showed, practically, no gain in accuracy. This was probably due to the ennui and lack of interest which were evident in the case of this subject. The latter's record showed the phenomenal rise in error of sixty per cent on the one hundred and fourth day for which no explanation could be found.

It was very hard for the subjects to concentrate the attention

on the work when any unusual noise was going on near-by, or if any one came into the room the distraction was always disadvantageous. As an illustration, one day when Subject G was doing the test in about three minutes, a person came into the room and walked by the table where the experiment was being conducted. Although he said nothing at all the time rose to four and three-fourths minutes. Subject G is rather sensitive to any distracting influences, but during the process of these tests he became less susceptive to such distraction, and toward the end could work unaffectedly under rather adverse conditions. This, too, shows the effect of practice in habit formation. Fatigue or indisposition also affected the tests unfavorably.

Conclusion.

It was found in this experiment that the practice curves took the typical form, that is, beginning rather high and gradually descending with the natural fluctuations in time, for the daily practices. However, these curves do not show the phenomenal drop at the beginning that many practice curves have. This is presumably due to the fact that all adults of a literary vocation are more or less familiar with and accustomed to adding figures, and thus eliminate the extreme slowness at the beginning which is found when the experiment deals with a matter that is strange and new to the subject.

It was found that the changes made in the method of adding with reference to the direction of columns, for the purpose of eliminating as far as possible the influence of memory, when made from the vertical to the horizontal always produced marked retardation, but if made from the horizontal to the vertical, an increase in time never occurred.

The error records show an efficient improvement in accuracy for Subject G, but for Subject K, little gain in accuracy was achieved. In the case of the latter subject, no interest entered into the tests and the ennui and drudgery attached to the work itself retained the high per cent of error.

In this experiment concentration was found very difficult when the subject was fatigued, indisposed in health, or when unusual sources of distraction presented themselves. Distraction, however, toward the end of the experiment, was not so disturbing as during the early part of the experimental series. This shows that the habit of concentration had become materially strengthened.

The effect of practice is evident from both the tables and the curves. There was no great difference, barring temporary fluctuations due to changes, in the fluctuations of any specific period; but the difference between the time during the first few days of practice and the time during the last few days is quite noticeable. An average of the first ten tests of Series C minus an average of the last ten tests shows a gain in time of 1.617 minutes for Subject G. The difference of the average of the first ten tests minus the average of the last ten tests of Subject K shows a gain of 1.023 minutes.

EXPERIMENT IN ADDING—TIME IN MINUTES.

Table I.—Subject G.

	A.	B.	C.
October 22nd	4.16	5.50	5.00
October 23rd	4.25	4.84	3.97
October 24th	5.08	4.84	3.97
October 25th	4.00	4.42	5.37
October 26th	3.64	4.16	5.37
October 27th	4.50	4.33	4.08
October 28th	4.82	4.33	4.25
October 29th	4.23	4.00	4.28
October 30th	5.44	4.57	5.37
October 31st	4.00	4.50	4.30
November 1st	4.25	3.97	4.33
November 2nd	4.09	4.00	5.75
November 3rd	3.88	4.16	4.88
November 4th	3.50	3.35	4.42
November 5th	3.53	4.00	3.56
November 6th	3.50	3.50	3.88
November 7th	4.33	4.42	4.12
November 8th	3.84	5.25	4.47
November 9th	5.16	4.66	4.16
November 10th	3.61	4.33	4.63
November 11th	3.56	3.42	4.62
November 12th	3.12	3.69	3.33
November 13th	4.33	4.19	4.08
November 14th	3.52	3.42	3.25
November 15th	3.37	3.50	3.47
November 16th	3.37	3.64	3.54
November 17th	3.50	3.29	4.04
November 18th	2.84	3.84	3.42
November 19th	3.12	3.62	3.06
November 20th	3.96	3.25	3.27
November 21st	4.50	4.84	3.47
November 22nd	3.63	2,37	4.16
November 23rd	3.53	4.66	3.37
November 24th	3.36	3.54	4.33
November 25th	3.47	3.29	3.61
November 26th	3.12	3.12	3.16
November 27th	2.97	3.25	3.11
November 28th	3.66	3.30	3.12
November 29th	3.25	3.16	3.33
November 30th	3.03	2.98	3.00
December 1st	3.53	4.92	4.06
December 2nd	4.12	3.33	3.69
December 3rd	3.37	3.66	3.42
December 4th	3.39	4.36	3.16

December 5th	3.25	3.61	3.40
December 6th	3.33	3.80	3.28
December 7th	3.12	3.88	4.84
December 8th	3.69	3.65	3.16
December 9th	3.30	3.46	3.37
December 10th	3.66	3.46	3.88
December 11th	2.97	3.86	3.34
December 12th	2.90	3.50	3.03
December 13th	2.09	3.27	3.47
December 14th	3.08	4.50	3.30
December 15th	2.89	3.58	3.25
December 16th	2.97	3.80	2.92
December 17th	2.68	3.66	2.94
December 18th	2.58	3.16	3.34
December 19th	2.43	3.42	3.50
December 20th	2.58	3.42	3.36
December 21st	3.42	3.36	3.36
December 22nd	3.00	3.86	3.66
December 23rd	3.35	3.80	3.45
December 24th	3.37	3.33	3.30
December 25th	3.25	2.37	3.63
December 26th	2.90	3.30	2.92
December 27th	5.12	3.75	3.17
December 28th	2.80	3.02	3.11
December 29th	4.53	4.30	4.16
December 30th	3.81	3.94	4.75
December 31st	4.50	3.50	4.65
January 1st	4.16	3.75	3.80
January 2nd	4.25	4.25	4.54
January 3rd	4.36	3.38	3.62
January 4th	4.12	3.97	3.25
January 5th	3.91	3.75	4.53
January 6th	3.54	3.87	3.54
January 7th	3.25	4.04	3.42
January 8th	3.50	3.28	3.27
January 9th	3.28	3.63	3.80
January 10th	4.25	3.33	2.97
January 11th	2.92	3.16	3.11
January 12th	2.80	2.47	4.08
January 13th	3.09	3.25	3.04
January 14th	2.97	3.20	3.37
January 15th	2.98	5.09	3.11
January 16th	3.08	3.84	3.07
January 17th	2.75	3.08	3.27
January 18th	3.42	3.92	4.16
January 19th	3.30	3.84	3.84
January 20th	3.42	3.50	4.37
January 21st	3.67	3.49	3.49
January 22nd	3.47	3.44	3.37
January 23rd	3.09	3.28	3.04
January 24th	2.67	3.12	2.97
January 25th	3.20	3.58	2.60
January 26th	2.84	3.16	3.20
January 27th	3.37	3.30	2.84
January 28th	2.75	3.28	3.03
January 29th	4.11	3.55	*
January 30th	*	3.58	3.42
January 31st	3.42	3.62	3.42
February 1st	3.11	3.20	2.75
February 2nd	3.00	3.26	3.05
February 3rd	3.50	3.08	3.25
February 4th	2.54	3.30	2.84
February 5th	3.66	3.56	2.85

February 6th	4.33	3.40	3.12
February 7th	3.54	3.40	3.89
February 8th	3.42	3.70	3.87
February 9th	3.12	4.16	2.92
February 10th	3.32	3.92	3.45
February 11th	3.30	3.64	3.59
February 12th	3.68	3.38	3.50
February 13th	2.97	3.96	3.30
February 14th	2.52	3.20	3.58
February 15th	3.37	3.34	2.92
February 16th	2.76	3.03	3.12
February 17th	2.94	3.46	2.16
February 18th	2.59	3.25	3.53
February 19th	2.80	3.10	4.00
February 20th	2.50	3.08	3.62
February 21st	2.50	2.62	4.08
February 22nd	3.11	3.04	3.00
February 23rd	2.56	2.59	3.08
February 24th	2.80	3.00	2.66
February 25th	3.26	2.88	3.00
February 26th	3.04	3.20	3.19
February 27th	2.74	2.78	3.04
February 28th	2.75	3.05	3.06
March 1st	3.04	2.96	2.84
March 2nd	3.08	2.73	3.06
March 3rd	2.30	2.59	3.28
March 4th	2.46	2.54	3.33
March 5th	2.92	2.86	2.53
March 6th	2.55	2.80	2.94
March 7th	2.97	2.80	3.00
March 8th	2.97	2.80	3.00
March 9th	2.42	2.84	2.28

Table II.—Subject K.

October 22nd	3.86	November 19th	2.92
October 23rd	3.86	November 20th	2.84
October 24th	3.67	November 21st	2.66
October 25th	3.69	November 22nd	3.37
October 26th	3.82	November 23rd	3.54
October 27th	*	November 24th	3.33
October 28th	3.78	November 25th	3.25
October 29th	4.05	November 26th	3.16
October 30th	3.55	November 27th	3.16
October 31st	3.84	November 28th	3.50
November 1st	3.84	November 29th	3.53
November 2nd	3.72	November 30th	3.16
November 3rd	3.33	December 1st	3.42
November 4th	3.61	December 2nd	4.66
November 5th	3.48	December 3rd	3.82
November 6th	3.76	December 4th	3.53
November 7th	4.16	December 5th	3.47
November 8th	4.55	December 6th	3.66
November 9th	3.33	December 7th	3.83
November 10th	3.72	December 8th	3.47
November 11th	3.50	December 9th	3.50
November 12th	3.16	December 10th	3.44
November 13th	3.66	December 11th	3.26
November 14th	3.18	December 12th	3.34
November 15th	3.09	December 13th	3.42
November 16th	3.11	December 14th	3.17
November 17th	3.08	December 15th	3.33
November 18th	3.38	December 16th	3.37

*Period missed.

December	17th	3.03	
December	18th	2.94	
December	19th	4.06	
December	20th	3.84	
December	21st	2.78	
December	22nd	2.75	
December	23rd	4.16	
December	24th	4.75	
December	25th	3.92	
December	26th	3.25	
December	27th	3.33	
December	28th	3.27	
December	29th	3.10	
December	30th	4.25	
December	31st	4.42	
January	1st	3.50	
January	2nd	3.16	
January	3rd	2.92	
January	4th	3.92	
January	5th	3.08	
January	6th	3.00	
January	7th	2.84	
January	8th	3.42	
January	9th	3.84	
January	10th	2.92	
January	11th	2.95	
January	12th	2.92	
January	13th	2.97	
January	14th	3.06	
January	15th	3.09	
January	16th	3.08	
January	17th	2.92	
January	18th	2.75	
January	19th	3.43	
January	20th	3.25	
January	21st	3.47	
January	22nd	3.30	
January	23rd	3.12	
January	24th	3.00	
January	25th	2.80	
January	26th	2.83	
January	27th	3.20	
January	28th	3.11	
January	29th	3.08	
January	30th	3.08	
January	31st	3.11	
February	1st	3.04	
February	2nd	3.19	
February	3rd	3.35	
February	4th	3.19	
February	5th	2.86	
February	6th	2.98	
February	7th	2.85	
February	8th	2.92	
February	9th	3.22	
February	10th	3.16	
February	11th	3.12	
February	12th	3.47	
February	13th	2.92	
February	14th	3.08	
February	15th	2.75	
February	16th	3.12	
February	17th	3.35	
February	18th	3.19	
February	19th	3.14	
February	20th	3.00	
February	21st	2.81	
February	22nd	3.20	
February	23rd	3.12	
February	24th	3.22	
February	25th	2.75	
February	26th	2.76	
February	27th	2.75	
February	28th	2.84	
March	1st	2.66	
March	2nd	3.00	
March	3rd	3.03	
March	4th	2.96	
March	5th	2.94	
March	6th	2.68	
March	7th	2.50	
March	8th	2.44	
March	9th	2.77	

USES OF FELDSPAR.

The feldspar quarries in the United States, with the exception of those in California, are restricted to nine of the eastern seaboard states. Most of the feldspar mined in the eastern states is of the potash or the soda variety or a mixture of the two, and these varieties are used in the pottery industry because, after being melted and cooled, they form a glass. Feldspar of the lower grade is used as a binder in making emery and corundum wheels, in manufacturing opalescent glass, as a poultry grit, as a constituent of roofing material and for surfacing concrete work. Small quantities of the purest grades of potash feldspar are used in the manufacture of artificial teeth.—*U. S. Geological Survey.*

REPORT ON VOCATIONAL MATHEMATICS.[1]

PART I.—THE APPLICATION OF ALGEBRA, GEOMETRY, AND TRIGONOMETRY TO THE PROBLEMS OF INDUSTRY.

The last report of this committee was confined almost entirely to the subject of arithmetic and the most elementary algebra as applied to the problems of trade, industry, and agriculture. In that report it was stated that it was our opinion that the highly specialized courses in shop arithmetic, carpenters' arithmetic, etc., ought to be confined to trade schools, continuation schools, and to special vocational classes for those who had chosen their life work. The need in these courses is specialization. The need in our public and secondary school (and college) courses is vitalization. Vitalization does not mean formal problems only. It does mean practical application even though incidental, for the contact of mathematical theory with ordinary practical life can be brought out in many incidental ways, no less forcibly because incidental. For instance the notions involved in the determination of a plane are put into practical use in many ways. The door swings upon its hinges (two points) until held by the latch (third point); the tripod for the camera as against the jiggling chair; the workman laying a cement walk and using two parallel lines (boards on each side), moving a straightedge along them. Vocational or vitalized mathematics in this sense means mathematics, the controlling purpose of which is to illustrate those points of contact with ordinary life where the same notion or concept functions. In this report we shall endeavor to give some information as to where vitalizing material for more advanced mathematics may be found and what should be the attitude of the teacher toward it and some of the points to be emphasized in the teaching of these subjects to students interested in the industries, agriculture, and domestic science.

I. The Application of Algebra to the Problems of Industry.

There is a difference between the teaching of vocational arithmetic and the teaching of vocational algebra, geometry, and trigonometry which must be recognized at the outset. There is such a thing as shop arithmetic, carpenters' arithmetic and plumbers' arithmetic, etc., in which certain principles of arithmetic are applied to the problems of these trades. A very limited knowledge of arithmetical operations is sufficient to enable the student to master the subject. The specific application of these principles

[1]Read before the Mathematics Section of the Central Association of Science and Mathematics Teachers at Chicago, November 26, 1915.

and operations is the difficult thing; hence, the need of the teacher who knows the trade.

Algebra has fewer specific applications and a better knowledge of this subject as a whole is required in order to make it useful to the tradesman. Hence we may say that vocational algebra differs less from academic algebra than vocational arithmetic does from general arithmetic. This does not mean, however, that the teacher of vocational algebra should be of an academic turn of mind. Advanced mathematics can be vitalized only when the teacher has a knowledge of its use in the vocations or at least in one specific vocation in which he is himself especially qualified, and a deep interest in their application to other vocations. As one of the members of this committee has stated, the viewpoint of the teacher of vocational algebra must be functional rather than analytical. He must show what algebra is good for, and keeping this idea constantly in mind, illustrate the use of algebra with good applications.

There are three particular subjects for the interpretation and understanding of which the average worker needs algebra. They are: 1, Formulas; 2, Equations; 3, Graphs. (And the greatest of these is equations.)

The shop algebra taught in trade schools is usually the subject of formulas only, in which all that is necessary for solutions is the substitution of numerical values. This is an excellent way to introduce the subject to the shopman for it indicates to him at once the usefulness of the subject. Such formulas as the following are the kind referred to:

$C = \pi D$, for the circumference of circle.

$L = 3\frac{1}{4}\ \frac{(D+d)}{(\ 2\ )} + 2C$, for the length of an open belt.

$T = D - \frac{1.3}{N}$, for tap drill for U. S. Standard threads.

$H.\ P. = \frac{D^2N}{2.5}$, for horse power of a gasoline engine.

$\frac{D-d}{L} = T$, for taper per inch of piece of work.

It is easy to see that if any variation is made from the given form of any one of these formulas, the whole subject of equations is opened up and as soon as a man has the formula $A = \pi r^2$, the subject of quadratics is before him.

It then amounts to this in teaching vocational algebra. Lead the student on to study more algebra because he *needs* it in order to be able to perform certain operations which he can see must

be performed before he can get from the formula the result which he desires. The next step is, of course, the forming of equations from given conditions. This belongs chiefly to the province of engineering and not to industry.

As to the amount of algebra necessary for the average worker, a knowledge of principles sufficient to enable him to solve ordinary equations including pure and affected quadratics is enough. For the average shopman the affected quadratic is not really necessary. The stationary engineer needs more than the shopman and should be drilled in logarithms as a part of his work. All tradesmen should be taught how to use tables and formulas as given in trade handbooks in order to obtain the actual numerical value needed. In fact, *numerical values* should be obtained for all solutions. General results in symbolic form, as such, should not be the teacher's aim in teaching vocational students.

As a field for the application of algebra, the machine shop, pattern shop and foundry are limited, provided we do not include work in actual design. In design, of course, applications are innumerable and algebra indispensable. As a special field for algebraic equations in industry, stationary engineering and millwrighting seem to be the most fruitful.

Graphs.

The subject of graphs has been mentioned as an important one. A shopman should be taught this thoroughly, introducing the subject as "Reading Diagrams." A man with only elementary knowledge of arithmetic can read a diagram correctly. The data sheets published by *Machinery,* the current mechanical journals, and steam engineering magazines, such as *Power* and the *Practical Engineer,* are full of this material. After the reading of diagrams has been mastered comes the making of diagrams from actual data and tables. Here, again, the field of stationary engineering is a fruitful one and also that of heating and ventilation in which steamfitters, janitors, and firemen are interested.

II. The Applications of Geometry and Trigonometry to the Problems of Industry.

It is all very well to state that the chief reason for studying geometry and other mathematical subjects is that they give mental training and are a source of pleasure; but such a statement does not always have the desired effect; at least, upon pupils in vocational and technical schools. Here the question as to the use of the subject is often raised and must be answered. The

present portion of this report will be devoted to enumeration of some of the applications of geometry and trigonometry.

Geometry may be said to be a less technical subject than trigonometry in the sense that it rests more directly upon experience. In contact with the material world, a person more or less unknowingly gains a great fund of geometrical facts, but it is not so with the more artificial subject of trigonometry. It is also true that geometry is often applied unknowingly to problems which arise in various activities. The study of geometry is to call attention to geometrical facts, to systematize them, and to lead one to apply them knowingly.

Space does not permit the giving of an exhaustive list of applications; but a somewhat classified list from plane geometry is given and in addition some hints as to applications in solid geometry and trigonometry.

I. In the first chapter of plane geometry, that dealing with straight-line figures, the applications are not so numerous as in other parts of the subject.

1. The triangle as the unit of rigidity is seen in frameworks, bridge structures, water towers, windmills, stepladders, and bracings in buildings.

2. The mechanic tests his square by using the fact that only one perpendicular can be erected to a line at a point in the line.

3. The draftsman uses the theorem that lines perpendicular to the same line are parallel, in drawing parallel lines.

4. Theorems referring to the parallelogram are made use of in planning telephone extension supports and light adjusters.

5. If three or more lines intercept equal parts on one transversal, they intercept equal parts on every transversal is made use of in dividing a board into any number of strips of equal width.

II. In the chapter on circles, there are:

1. Applications in pulley and gear wheels.

2. Applications in laying out work of various kinds—such as designs for windows, moldings, and floors.

3. That an angle inscribed in a semicircle is a right angle is used by the mechanic in drawing a circle with the steel square, and in testing a circle.

III. In the chapter on areas are found many applications.

1. Formulas for finding areas of figures in forms of rectangles, parallelograms, triangles, and trapezoids. Such are areas of walls and floors, areas of various forms made from sheet

metal, cross-sections of I-beams and channel irons, areas of fields.

2. Approximate rules for finding areas of irregular shapes, such as the trapezoidal rule.

3. The Pythagorean theorem as used in finding the lengths of braces, sums of areas of squares, exemplified by use of steel square.

4. Uses of $\sqrt{2}$ and $\sqrt{3}$ in finding diagonal of square and altitude of equilateral triangle, as applied to finding size of square and triangular ends that may be milled on round shafts, to lengths of steam pipes, and to size of square reamer to make hole of a given dimension.

5. The computation of the radius of a circle when height and width of segment are given. This has applications in work with arches and in railway curves.

IV. In the chapter on proportion and similarity, applications are more numerous.

1. Similar triangles applied to finding the distance across a stream, heights of trees, etc.

2. Drawing to scale.

3. Numerous uses of the plane-table.

4. Applications in use of proportional dividers, sectors, pantograph, diagonal scale, and other instruments.

5. Applications in determining depths of screw threads and to tapers.

6. Use of carpenter's square in cutting braces, rafters, and miters.

V. In the chapter on regular polygons and measurement of circles there are:

1. Constructions in polygons and designs depending upon them.

2. Use of carpenter's square in adding areas of circles, applied to areas of pipes.

3. Areas of circles in a great variety of applications.

4. Areas of rings; many uses.

5. Areas of segments, used in connection with steam boilers and in sheet metal work.

6. Designs for windows, parquetry, and doilies.

7. Speeds of gear wheels and pulleys.

8. Cutting speeds in turning.

Trigonometry is applied to solving various interesting and useful problems as well as being an aid in higher mathematics. When taught with the direct applications in view, the main stress should

be upon the solution of triangles; but, when taught to students who are to pursue the study of more advanced mathematical subjects, transformations and the manipulations of formulas should be emphasized. The applications are numerous and cannot be mentioned in a short space in detail.

PART II.—THE APPLICATION OF ALGEBRA, GEOMETRY, AND TRIGONOMETRY TO THE PROBLEMS OF AGRICULTURE.

Students in agriculture form, as a general rule, a heterogeneous group as far as their mathematical preparation and attainments are concerned, and for this reason, the work in mathematics should be such as not to deaden the interest of the better nor discourage the poorer student. For this reason a very brief review of the very elementary parts of algebra and geometry with numerical exercises should be given at the beginning.

Nearly all students have occasion after they leave school to use the very elements of geometry. This use may come about through the design and location of buildings, through the survey of land, both as to location and to finding of distances and of areas, through the problems of drainage and irrigation, etc. This use of elementary geometry should be introduced, in concrete form as far as possible, throughout the entire course. The trigonometry may be taught to these students as though it were a part of elementary geometry with only the introduction of a few new terms and tables to facilitate the work. It is unnecessary to make this work appear formidable by using the term trigonometry.

In reviewing elementary algebra and throughout the entire course, the student should be encouraged to apply algebraic operation and methods to numerical problems. Students certainly need, and need very badly, practice in numerical calculation. In this connection as in all other work, they should be taught in such a way that they will acquire the habit of looking at the problem in hand from all sides and of looking ahead to see how the work can be shortened as much as possible. To illustrate, take the division by the square root in mensuration of plane figures. To make it specific let us find the length of the side of a square whose diagonal is 100 feet. The length of the side is, in feet, $\frac{100}{\sqrt{2}}$ Most, if not all, students will not stop to look at this expression a second time but will immediately divide 100 by 1.414, instead of considering the transformation.

$$\frac{100}{\sqrt{2}} = \frac{100\sqrt{2}}{2} = 100 \times 0.707 = 70.7.$$

The student does not seem to realize, at first, that dividing by a number consisting of several digits is more tedious and requires more time than multiplying by the same number and dividing by a number of a single digit.

One of the problems with which all students of agriculture will have to deal is that of studying and analyzing statistical data representing readings connecting two variables. Of course, those readings should first of all be plotted upon squared paper, thus producing a picture of the variation of the variable represented by the data at hand. In studying the methods of representing statistical data by plotted points or by graphs, the student should have careful instruction regarding the choice of scales to be used on the two axes, in order that the whole picture, and especially its salient features, may stand out clearly to the eye. Also the importance of making a neat and accurate picture and of marking the axes and other important parts of the drawing can not be overemphasized.

In performing nearly all experiments in which reading are taken connecting two variables, the fundamental object is to try to discover some law of nature. The table of readings represents this law. The graph obtained from the readings represents this law, and if the graph is a regular curve, it may be possible to represent the law by a simple empirical equation. If the relation connecting the variables is a simple law and if the empirical equation can be found, the student will soon learn the desirability of finding this equation. He will soon learn that it is a very convenient and useful form of expression. Take, for example, the very simplest case, where the plotted points arrange themselves along a straight line passing through the origin. To say that y varies directly as x is a simple and concise form of expression. But the student who has had even a very little instruction in plotting will prefer to make the graph. When he sees the equation, he sees, in imagination, the straight line, and when he sees the straight line, he thinks of the equation and can easily find the factor of proportionality.

Throughout the course in mathematics for agricultural students, numerical exercises should be given, and, whenever the calculations are simple, logarithms (or the slide rule) should be used in so far as they give the desired degree of accuracy. It is not enough in logarithms to teach the rules for multiplication,

division, evolution, and involution; the rules for determining characteristics, and the arrangement of the logarithmic and trigonometric tables should be given. The instructor has the more important task of teaching the student how to use logarithms, how to use a table, how to arrange numerical work, and how to save time by doing neat, careful, and systematic work. It is a deplorable fact that in a large per cent of the instruction given in the subject of logarithms, no instruction at all, or but very little instruction, is given in real useful numerical calculation. Why? Because the instructor does not know or because he has not the ability, or possibly because the instructor wishes to avoid this tedious grind which throws considerable extra work upon himself.

A large wall slide rule, eight or ten feet long, should be in the classroom and used by the instructor. From this example set by the instructor, by the end of the semester from one-third to one-half of the students will have purchased and will be using slide rules.

The work in trigonometry should be cut down to a minimum. Only enough should be given to enable the student to solve numerical problems in finding lengths, heights, and areas.

This applies to the teaching of mathematics to four-year agricultural students who enter college after completing a high school course. The mathematics which should be given these students can be termed neither vocational nor practical mathematics. It is, however, useful mathematics—useful in that it will be helpful to the student in pursuing other scientific studies, and, perhaps, helpful in later life, in a practical way.

The principal subjects with their applications as indicated above are:

The application of elementary algebra and geometry to problems of interest to the student. These applications to be introduced whenever possible throughout the entire course.

Numerical calculations, both with and without the use of logarithms. In this work especial emphasis to be placed upon orderly and systematic arrangement of work.

Graphic representation of statistical data, with a few simple exercises in finding empirical equations.

Trigonometry, in so far as it will enable the student to determine distance and areas.

PART III.—THE APPLICATION OF ARITHMETIC, ALGEBRA, AND GEOMETRY TO THE PROBLEMS OF DOMESTIC SCIENCE.

Under this heading the subject of arithmetic is included because its application to domestic science was not discussed in the report of last year. Trigonometry has not been found useful to any extent in domestic science and is therefore omitted.

The following discussion and outline combine the ideas of a number of teachers who have had experience in grade, high school, college and continuation school-teaching of domestic science or home economics subjects. All have emphasized the need of fractions, percentage, and oral drill in fundamental processes throughout the entire course. Anything which has to do with figures immediately becomes associated with something very difficult in the minds of even high school and college girls and they become dazed and bewildered. This would not be true if the mathematics teacher had given problems which applied the principles to actual experience met in other classes and in daily life. It is one thing to do a list of examples when the figures are all arranged in the proper order and the answer is found in the back of the book, and quite another to take a problem, even though it involves the same processes, reason it out and put it into workable form. It is the latter which confronts the girl when she is figuring the cost of a menu, working out a draft, or making up a five per cent solution of K O H.

The mathematics and domestic science teachers by working together construct some problems which would make mathematics more interesting and practical for the pupils, and at the same time prepare the girls for the problems which they will meet in the domestic science classes and later in daily life.

The following outline gives the chief applications of mathematics to problems of domestic science and home economics.

I. Arithmetic.

1. Fundamental processes and common fractions (applications obvious).
2. Weights and measures (English and metric)—(a) marketing; (b) calculation of heating values in calories; (c) daily rations; (d) reading of gas meters, water meters, and electric meters, and determination of costs; (e) time saved by mechanical devices.
3. Accounting—(a) bank accounts; (b) home and school equipment costs; (c) comparative costs of hand and machine work; (e) cost of installation and operation of heating systems; (f) cost of fuels; (g) yearly budgets; (h) division of income.
4. Percentage—(a) food constituents and food values; (b) daily menus; (c) adulterations in textiles; (d) specific gravity solutions.
5. Ratio and proportion—(a) nutritive ratio; (b) mixing ingredients; (c) chemical formulas; (d) problems of design.
6. Mensuration, including some geometrical work—(a) carpeting; (b)

flooring; (c) papering; (d) measurements of bed linen, table linen, curtains, and clothing; (e) ventilation, cubic feet of air needed and changes of air necessary.

II. Algebra.

1. Equations, applied to formulas and simplest forms of algebraic expressions.
2. Graphs—(a) daily temperature; (b) oven temperature, as in bread making; (c) calories in daily food; (d) yearly expenses; (e) temperatures and humidity.

III. Plane Geometry.

1. Straight-line figures—(a) drawing of all kinds and drafting of patterns; (b) picture hanging; (c) fireplaces; (d) fixtures.
2. Circles and curved figures—(a) stencils; (b) designs for carpet, linoleum, floors, molding, parquetry, and windows.
3. Areas and mensuration. Same as arithmetic.
4. Triangles, polygons, circles, etc.—(a) design.

IV. Solid Geometry.

1. House construction.
2. Foundations.
3. Concrete work.
4. Excavation costs.
5. Tank volumes.

Conclusion.

The above report compiled by different members of this committee engaged in different lines of work in different parts of the country seems to indicate several things very clearly.

1. More drill on fundamental processes is necessary in order to secure facility in computation.

2. Applications formal and incidental should be emphasized. The average student does not easily bridge the gap between principles and application.

3. Co-operation between mathematics teachers and those engaged in other lines in which mathematics is used is absolutely necessary.

4. Study and thought on the part of the teacher are necessary if sound, useful, and interesting applications are to be found and made available for teaching.

5. Some mathematics teachers have a very thorough knowledge of mathematics as a science and a very limited knowledge of its application. Such teachers are not good teachers of vocational mathematics.

K. G. SMITH, *Chairman.* ANNABEL TURNER.
C. I. PALMER. C. A. PETTERSON.
H. C. WOLFF. MYRTLE FERGUSON.

NOTE ON THE LAW OF TANGENTS.

By E. R. Hedrick,
University of Missouri, Columbia, Mo.

Referring to the interesting article by Mr. R. W. Mathews on the proof of the Law of Tangents, which appeared on page 798 of the December issue of School Science and Mathematics, I wish to add a few comments, since it seems to me that the formula is indeed one which deserves considerable attention.

The proofs mentioned by Mr. Mathews are for the most part known through existing texts which he quotes. The variations which he proposed are in themselves of interest and ought to be studied by teachers of trigonometry.

I wish to add to the list which he has suggested a proof which I devised and which seems to me to be very vivid.[1]

Let ABC be any triangle having two sides a and b unequal, say $a>b$; the included angle C may be acute, right, or obtuse.

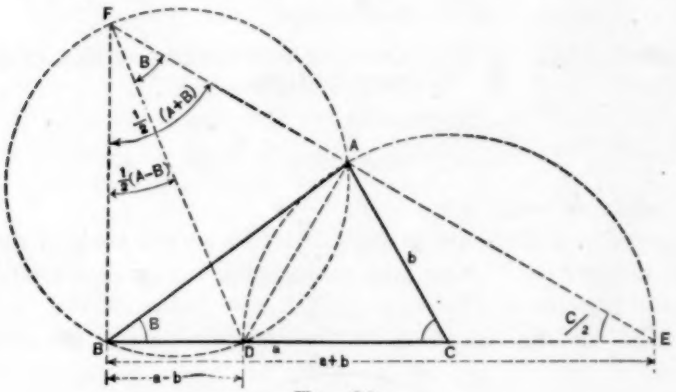


Fig. 29

With a radius b, the shorter of the given sides, and center C, the vertex of the included angle, describe a circle through A which cuts the side CB in a point D between B and C and also at a second point E beyond C. Draw EA, and at B erect a perpendicular which meets EA produced at F. On DF as a diameter construct a circle; this circle will pass through A and B, for FAD is a right angle since it is the supplement of DAE which is inscribed in a semicircle, and FBD is a right angle by construction. This construction is possible for any triangle in which $a>b$.

[1]This proof is used, with my consent, by Kenyon and Ingold, *Plane and Spherical Trigonometry*. The Macmillan Company. This book was apparently not in Mr. Mathews' hands.

The angle BFE = (A+B)/2, since it is the complement of CEA = C/2, and (A+B+C)/2 = 90°. The angle DFA is equal to B, since both angles intercept the same arc AD; hence, BFD = BFE—DFA = (A—B)/2.

In the right triangles DBF and EBF,

$a-b$ = BF tan [(A—B)/2], and $a+b$ = BF tan [(A+B)/2].

Therefore,

$$\frac{a-b}{a+b} = \frac{\tan [(A-B)/2]}{\tan [(A+B)/2]}$$

The advantage of this proof is that the angles 1/2(A—B) and 1/2(A+B), which occur in the formula not only appear as angles of the figure, but also they turn out to be angles at the same vertex in triangles which have a common base, so that the law can be read off instantly from the figure.

After some attention to this matter the vividness of the geometrical picture afforded by this diagram seems to me to give it a certain advantage over other proofs with which I am familiar.

GEOMETRICAL PROOFS OF THE FORMULAS, SIN2β, COS2β, SIN3β, and COS3β.

By Clifford N. Mills,

South Dakota State College.

I. $\sin 2\beta = 2\sin\beta\cos\beta$.

Inscribe in a circle any triangle, ABC, with the angle B equal to 2β (Figure 1). Draw AM through the center of the circle; BK, the bisector of the angle B; OK, the radius of the circle; AK, KM, and KC, K being on the circumference of the circle.

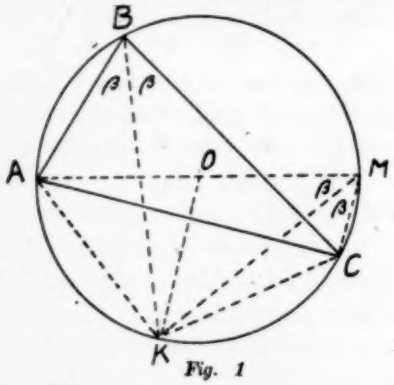


Fig. 1

Then $\sin 2\beta = \frac{AC}{2r}$.

△'s AKC and KOM are similar isosceles triangles.

Hence, $\frac{AC}{AK} = \frac{KM}{r}$ or $AC = \frac{AK \cdot KM}{r}$.

Hence, $\frac{AC}{2r} = \frac{AK \cdot KM}{2r^2} = \frac{2AK \cdot KM}{4r^2}$,

But, $\frac{AK}{2r} = \sin\beta$ and $\frac{KM}{2r} = \cos\beta$.

Hence, $\sin 2\beta = 2\sin\beta\cos\beta$.

II. $\cos 2\beta = \cos^2\beta - \sin^2\beta$.

Using Figure 1, we get,

$$\cos 2\beta = \frac{MC}{2r} = \sqrt{\frac{4r^2 - \overline{AC}^2}{(2r)^2}} = \sqrt{1 - \frac{\overline{AC}^2}{4r^2}}.$$

But, $AC = (AK \cdot KM)/r$.

Hence, $\cos 2\beta = \sqrt{1 - \frac{\overline{4AK}^2 \cdot \overline{KM}^2}{16r^4}}$.

Substituting the values of AK and KM, as previously found, we have,

$$\cos 2\beta = \sqrt{1 - 4\sin^2\beta\cos^2\beta} = \cos^2\beta - \sin^2\beta.$$

III. $\sin 3\beta = 3\sin\beta - 4\sin^3\beta$.

Inscribe in a circle any triangle ABC with the angle B equal to 3β (Figure 2). Draw AM, the diameter of the circle. Arc AH = arc HK = arc KC. Draw the chords—AK, HC, KC, HM, KM, BH, and BK. Then

$$\sin 3\beta = \frac{AC}{2r}.$$

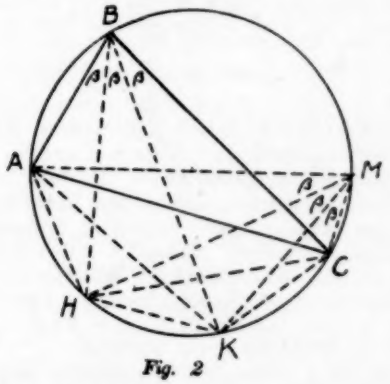


Fig. 2

AHKC is a concylic quadrilateral.

Hence, $AC \cdot HK + AH \cdot KC = AK + HC$,

or, $AC \cdot AH + \overline{AH}^2 = AK \cdot HC = \overline{AK}^2$,

whence, $AC = (\overline{AK}^2 - \overline{AH}^2)/AH.$

But, $AK = HC = 2r \sin 2\beta = 4r \sin\beta\cos\beta,$

and, $AH = 2r \sin\beta.$

Hence, $\sin 3\beta = \dfrac{16r^2\sin^2\beta\cos^2\beta - 4r^2\sin^2\beta}{4r^2\sin\beta} = 3\sin\beta - 4\sin^2\beta.$

IV. $\cos 3\beta = 4\cos^3\beta - 3\cos\beta.$

From Figure 2, we have

$$\cos 3\beta = \frac{MC}{2r}.$$

Now, $\dfrac{\overline{MC}^2}{4r^2} = \dfrac{4r^2 - \overline{AC}^2}{4r^2}.$

But, $\overline{AC}^2 = \dfrac{\overline{AK}^4 - 2\overline{AK}^2 \cdot \overline{AH}^2 + \overline{AH}^4}{\overline{AH}^2},$

Hence, $\dfrac{\overline{MC}^2}{4r^2} = 1 - \dfrac{\overline{AK}^4}{4r^2\,\overline{AH}^2} + 2\,\dfrac{\overline{AK}^2}{4r^2} - \dfrac{\overline{AH}^4}{4r^2}.$

Substituting the values of AK and AH, we have

$$\frac{\overline{MC}^2}{4r^2} = 16\cos^6\beta - 24\cos^4\beta + 9\cos^2\beta.$$

or, $$\frac{MC}{2r} = 4\cos^3\beta - 3\cos\beta.$$

Hence, $\cos 3\beta = 4\cos^3\beta - 3\cos\beta.$

REPORT ON FELDSPAR.

The marketed production of feldspar in 1914 amounted to 135,419 short tons, valued at $629,873, according to the annual statement on the production of feldspar now available for distribution by the United States Geological Survey.

DEAN CALDWELL AT EMPORIA, KANSAS.

Otis William Caldwell, Professor of Botany and Supervisor of Natural Science in the School of Education at the University of Chicago, has accepted an invitation to deliver a series of lectures on "High School Science" before the State Normal School at Emporia, Kansas, during the week beginning June 25th. Among the topics to be discussed by Professor Caldwell will be reasons for teaching science; principles of selection and organization of elementary-school work in science; science and modern life; general science, its purpose, organization, and method; and nature-study literature for grade teachers.

Dr. Caldwell has made a special investigation of the methods of science teaching in secondary schools with reference to relating such teaching more closely to the facts of nature and life, and he will discuss the question of "The New Movement in the Teaching of Science" in an early number of the *School Review*.

THE STUDY OF PLANT DISEASES IN THE HIGH SCHOOL.[1]

By Dr. Melville T. Cook,
Professor of Plant Pathology, Rutgers College, New Brunswick, New Jersey.

It is unnecessary to review the difficulties which beset the path of the high school teacher of botany. We are all familiar with the fact that the pupils, parents and many of the teachers look up to the course in botany as a filler which must be tolerated, an aimless playing with flowers, the learning of Latin names, a course without relationship to other subjects and without application to the affairs of everyday life. This idea of botany is emphasized by the increasing number of vocational subjects for those who cannot or do not intend to pursue a college course.

These difficulties were partly overcome by the rise of plant physiology and ecology; the former directing the attention of the pupil to the life characters of the plant by means of experimental work in the laboratory, and the latter to the habits of growth and relationship of the plant to its environments. Unfortunately, the full value of these two phases of botany could not be realized because of the lack of well-trained teachers and shortness of time devoted to the subject. However, the rise of agriculture in the high schools promises to give botany a new inheritance.

If agriculture is to reach its highest development in the high school, it must recognize that botany is the foundation upon which it must build. In fact, botany must necessarily merge into agriculture so that the line of demarcation between the two will be almost imperceptible or largely arbitrary. This should result in a new viewpoint and a renewed interest in botany as a pure and applied science. It should result in the full appreciation of the fact that horticulture, agronomy and forestry are highly specialized branches of applied botany, and that a knowledge of the fundamental principles of botany are essential to the highest development of these specialized subjects.

The year in which botany shall be given, the phase of the subject to be presented, the manner of presentation, and the amount of time to be devoted to the subject, are questions on which there is a wide range of opinions. The line of demarcation between

[1]Resume of paper read at the nineteenth meeting of the New Jersey Science Teachers' Association, Battin High School, Elizabeth, N. J., December 11, 1915.

botany and agriculture introduces another factor into the already complicated problem which we may be long in solving.

However, if we fully appreciate the importance of botany as a foundation for agriculture, it will, no doubt, result in two things —(1) the placing of botany in the first part of the high school course; and (2) a greater appreciation of the importance of the subject. The change in viewpoint which must accompany this readjustment must necessarily bring about a change in methods of teaching. Botany must be taught as other subjects are taught, i. e., in its relation to other subjects and to everyday life. Reading is taught because it opens the door to other subjects. Reading, writing and arithmetic are taught because they can be and are used in affairs of everyday life. Every boy and girl in the high schools of our country sees the application of both chemistry and physics, and they are studied from this viewpoint, although not necessarily with the idea of an immediate application. The botany of the future will, no doubt, be taught more and more in the light of its relation to agriculture and its usefulness in our everyday affairs.

The rise of agriculture will, no doubt, lead to changes in subject matter presented to the pupils and in the method of presentation. Corn and beans cannot be planted and grown with a compound microscope to any better advantage than cloth can be measured with a set of surveyor's instruments. Aside from a few demonstrations, the compound microscope is almost as useless in teaching high school botany as a set of surveyor's instruments in the teaching of arithmetic and algebra. Very few high school pupils can interpret the compound microscope, and the time frequently devoted to this complicated piece of apparatus can be used to a much better advantage in the study of simple experiments illustrating the relation of light, temperature, water, soils and fertilizers to plant growth.

Thus far I have said nothing about plant diseases: My first impulse is to say that the study of plant pathology has no place whatever in the high school. Plant pathology is a highly specialized branch of botany and cannot be taught in the same manner as fundamental botany. In fact, it may, in some cases, be taught more properly as a part of agriculture. However, it can be used to show the viewpoint of modern botany, just as the electric doorbell and electric light can be used to emphasize the importance of the study of physics.

The agricultural losses due to plant diseases are enormous and

if presented properly will make a lasting impression on the minds of most pupils. The appreciation of the fact that these diseases are just as real as those which attack animals, that they are due to definite and, in many cases, well-known organisms, that they are infectious, and that they can in many cases be prevented, or controlled, is worthy of the ambition of any teacher of high school botany. These facts may be illustrated by simple experiments and demonstrations (with the microscope if necessary). If properly presented, they will serve to show the necessity of a more extended study of botany than can be given in the high school. The many agricultural experiment station bulletins on the control of plant diseases will serve as guides for the immediate application of botany to the local problems of agriculture and gardening.

The limitations of botany in the high school, and its position as a pure and applied science, will depend more on the teacher than on all other factors combined. Botany is a study of plants and not of books, and the most successful teachers will be those who can direct laboratory and field experiments to the best advantage.

CANCER DOES NOT RETURN!

The general impression that cancer is an absolutely hopeless disease and that surgery is a futile means of cure is often expressed by the not too well informed or the unfortunate. "What's the use? It always returns." In fact, it had long been believed, even by good surgeons, that a recurrence was, as the name implies, a return of the cancer after it had been completely removed. The present and more hopeful belief, and undoubtedly it is the correct one, is that the original malignant growth was not entirely removed. In other words, the recurrence is a definite and direct continuation of the original growth, of which at least a microscopic part was not removed. When the original growth is removed completely there is positively no danger of recurrence. In modern operations for cancer in order that the removal may be complete or that no tissue containing the dangerous microscopic cancer cells may remain, the organs or parts in which the growth is located are removed as widely as anatomical relations will allow. In the early stages cancer is a strictly local disease and the surrounding tissue only becomes involved as the disease progresses. If the growth is discovered and removed very soon after its inception the operation can hardly be classed even as "dangerous." If, through ignorance or fear, one procrastinates and does not permit operation until the growth has spread through the adjacent glands and tissue, the uncertainty of getting out all the malignant cells is greatly increased. So it is very easy to see that in the early removal of cancer lies the hope of cure—and the earlier the removal, the stronger the hope.

DATA ON TEXTBOOKS IN THE BIOLOGICAL SCIENCES USED IN THE MIDDLE WEST.[1]

By O. D. Frank,
Quincy, Ill., High School.

In order to find out what textbooks are being used here in the middle west in botany, zo-ology, biology, general science, physiology, physiography and agriculture, the committee who had charge of the Biology Section of the Annual Conference of the University of Chicago with Related Secondary Schools, asked me to ascertain the names of texts used in the above subjects, make analyses and charts of the first three mentioned to show data obtained and present them at the meeting.

In order to do this a questionnaire was sent to twenty-five high schools in each of the states of Illinois, Indiana, Iowa, Michigan, Missouri and Wisconsin. This questionnaire covered the following points:

1. Text used in botany, zoology, biology, general science, physiology, physiography and agriculture.
2. Subject offered as a whole or half year.
3. Number of girls and number of boys taking each subject.
4. Number of girls and number of boys in high school.
5. Name of teacher of each subject.

While the number of schools included is somewhat small they are rather broadly distributed over the six states concerned and it is believed that they are fairly representative. Answers were received from ninety-seven of the one hundred and fifty letters sent out.

The committee asked that an analysis be made of the four botany textbooks, the four zoology textbooks and the two biology textbooks most widely used. In making the analyses, each page of the text was studied and the part of the page devoted to each particular phase of the subject noted. This was reduced to percentage.[2]

An Analysis of Four Botany Textbooks.

It will be noted from the chart that plant physiology, ecology and economic botany hold prominent places in the majority of the texts analyzed. The wealth of illustrations in each of the four texts is also notable.

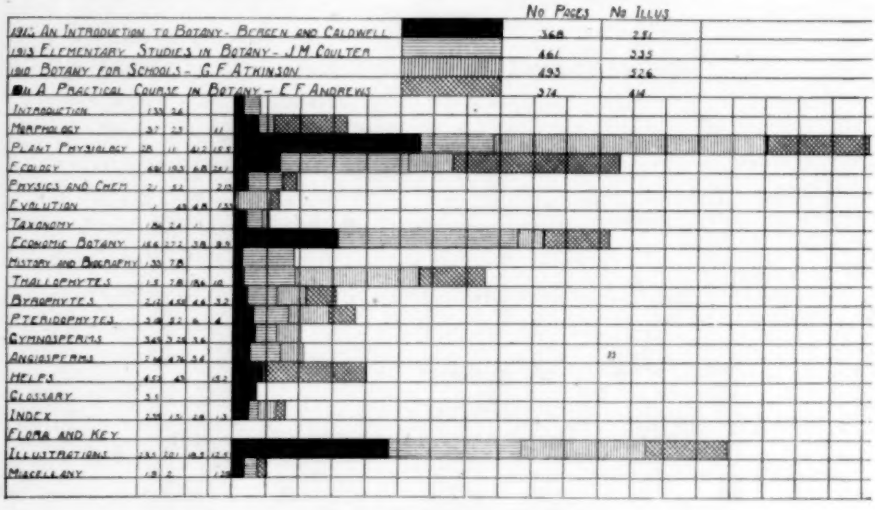
[1] Presented at University of Chicago Secondary School Conference, April 16, 1915.
[2] The charts were made by Donald Steers, a student in the manual training department of Quincy High School.

SUMMARY OF REPORT

		Botany	Zoology	Biology	Gen. Sci.	Physiology	Physiog.	Agriculture	High School	Totals
Average Enrollment:	Girls	35	20	46	49	30	42	16	424	
	Boys	21	21	26	61	21	42	62	368	
	Total	56	41	72	110	51	84	78	792	
Maximum Enrollment		126	87	184	444	132	410	102	2,600	
Minimum Enrollment		11	8	17	22	10	20	62	232	
Per cent of girls in each class		62	48	63	44	59	50	30		51
Per cent of boys in each class		38	52	37	56	41	50	70		49
Distribution of pupils according to subjects:	Girls, per cent	16	9	21	22	13	19	1		
	Boys, per cent	11	11	13	32	11	22	3		
	Total, per cent	13.5	10	17	27	12	20.5	2		
Per cent of woman teachers		54	50	55	60	70	57	27		53
Per cent of man teachers		46	50	45	40	30	43	73		47
Number of different texts used		10	7	1	5	17	6	4		
Per cent of schools offering the above subjects		82	54	25	33	54	74	13		
Per cent of schools offering the above subjects as a whole year		62	62	80	33	4	53	43		
Per cent of schools offering the above subjects as a half year		38	38	20	67	96	47	57		

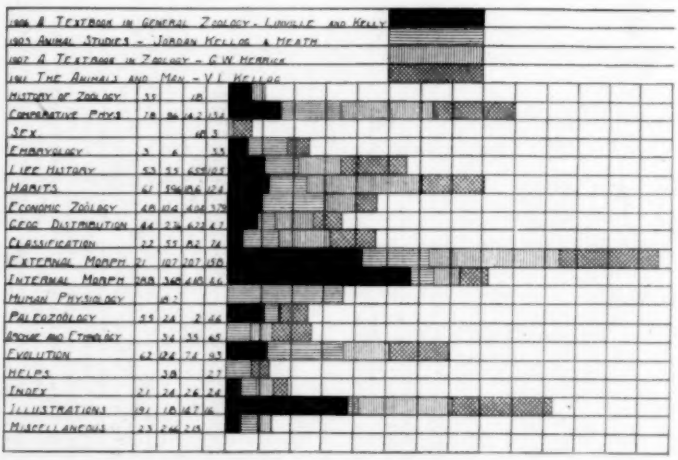
Two per cent of schools offer only one of the above subjects.
Twenty-one per cent of schools offer two of the above subjects.
Twenty-one per cent of schools offer three of the above subjects.
Forty-four per cent of schools offer four of the above subjects.
Ten per cent of schools offer five of the above subjects.
Twenty per cent of schools offer six of the above subjects.
No per cent of schools offers seven of the above subjects
Per cent of students taking botany as compared to zo-ology: Botany, sixty-six per cent; zo-ology, thirty-four per cent.
Per cent of students taking botany as compared to biology: Botany, sixty-nine per cent; biology, thirty-one per cent.
Highest per cent taking botany as compared to school enrollment: 29.1.
Highest per cent taking zo-ology as compared to school enrollment: 15.8.
Per cent of all students in high school taking science: Girls, 15.2; Boys, 13.6.

The amount of evolution and taxonomy which occupied a very prominent place in the botany texts of a few decades ago has dwindled materially.



An Analysis of Four Zoology Textbooks.

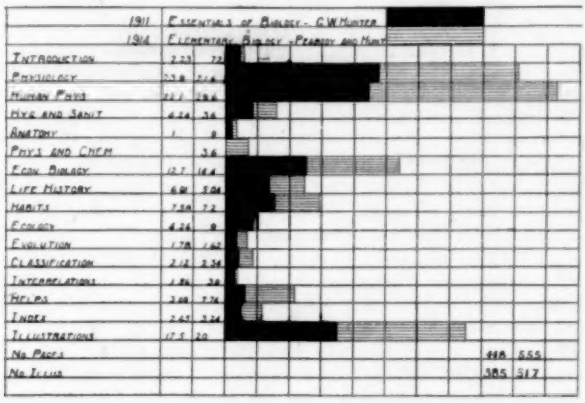
Evolution and morphology are emphasized more in zoology than in botany. In zoology, as in Botany, there is a high percentage of comparative physiology and of illustrations.



An Analysis of Two Biology Textbooks.

Here, too, as in botany and zo-ology, it is shown that the physiological and economic phases predominate, also the per-

centage of illustrations is large. May it not be that the large amount of physiology shown in the biology texts indicates a recognition of the fact that physiology represents the common meeting ground of botany and zoology, therefore the opportunity of the unification of these into general biology?



The titles and authors of the texts, together with the percentage of schools in which each is used are given below. The percentages are calculated in each case in relation to the total number of schools offering the subject. Eleven different textbooks in botany, six in zoology and two in biology were mentioned in the answers received.

BOTANY.

An Introduction to Botany, Bergen & Caldwell, is used in thirty-three per cent.

Four botany textbooks by J. M. Coulter[3] are used in thirty per cent.

Botany for Schools, G. F. Atkinson, is used in nineteen per cent.

A Practical Course in Botany, E. F. Andrews, is used in six per cent.

Plant Life and Plant Relations, J. G. Coulter, is used in four per cent.

Bergen's *Essentials* is used in three per cent.

Bergen's *Foundations* is used in three per cent.

Botany—L. H. Bailey, is used in two per cent.

ZOOLOGY.

A Textbook in General Zoology, Linville & Kelley, is used in seventy per cent.

The Animals and Man, V. L. Kellogg, is used in ten per cent.

Animal Studies, Jordon, Kellogg & Heath, is used in ten per cent.

A Textbook in Zoology, Glenn W. Herrick, is used in five per cent.

Animal Forms, Jordon & Kellogg, is used in three per cent.

Zoology—P. P. Colton, is used in two per cent.

BIOLOGY.

Essentials in Biology, George W. Hunter, is used in sixty per cent.

Elementary Biology, Peabody & Hunt, is used in forty per cent.

[3]In a number of instances the person answering did not designate which of J. M. Coulter's texts was being used. *Elementary Studies in Botany* being named most frequently it was the one analyzed.

ARTICLES IN CURRENT PERIODICALS.

American Botanist for November; Joliet, Ill.; $1.00 per year; "Heaths and Heath Plants," Willard N. Clute; "Latex," Willard N. Clute; "Liverworts," W. W. Bailey; "Vegetable Chimeras."

American Forestry for February; Washington, D. C.; $3.00 per year, 25 cents a copy; "The Douglas Fir—Identification and Characteristics" (three illustrations), S. B. Detwiler; "Commercial Uses of Douglas Fir" (ten illustrations), J. S. Williams; "The Tree of Legend and Romance" (nine illustrations), Mark Daniels; "Bird Department" (ten illustrations), A. A. Allen; "The Association's New President" (one photograph); "Lecturing in Chekiang" (one illustration), D. Y. Lin; "Nut-Growing, a New American Industry" (nine illustrations), William C. Deming; "Wood Preserving Department" (two illustrations), O. P. M. Goss; "Ornamental and Shade Trees" (four illustrations), William W. Colton.

American Journal of Botany for January; Brooklyn Botanic Garden; $4.00 per year, 50 cents a copy; "Physiological Observations on Alkaloids, Latex and Oxidases in Papaver Somniferum," Rodney H. True and W. W. Stockberger; "Notes on the Anatomy of Peridermium Galls," Alban Stewart; "The Climatic Distribution of Certain Types of Angiosperm Leaves," Irving W. Bailey and Edmund W. Sinnott; "A Gymnosporangium with Repeating Spores," J. C. Arthur.

American Naturalist for January and for February; Garrison, N. Y.; $4.00 per year, 40 cents a copy: "A Further Analysis of the Hereditary Transmission of Degeneracy and Deformities by the Descendants of Alcoholized Mammals," Dr. Charles R. Stockard and George Papanicolaou; "Fecundity in the Domestic Fowl and the Selection Problem," Dr. Raymond Pearl; "The Evolution of the Cell," The Late Professor E. A. Minchin; "Shorter Articles and Discussion—Inheritance of Congenital Cataract," D. F. Jones and S. L. Mason; "Huxley as Mutationist," Dr. R. Ruggles Gates.

Journal of Educational Psychology: Warwick and York, Baltimore; $2.50 per year, 30 cents a copy: "A Constructive Ability Test," Truman Lee Kelley; "Age Norms of Psycho-Motor Capacity," J. E. Wallace Wallin; "Efficiency in Mental Multiplication with Extreme Fatigue," W. S. Painter; "An Experiment on the Influence of Training on Memory," Edwina Abbott Cowan.

Geographical Review for February; American Geographical Society, Broadway at 156 Street, New York City; $5.00 per year, 50 cents a copy: "The Great Russian Retreat" (6 maps, 6 photos), Douglas Wilson Johnson; "Protection from Damage by Frost" (8 photos), William Gardner Reed; "The Wireless Determination of the Washington-Paris Longitude," David Rines; "Russia's War-time Outlets to the Sea" (map); "The Washington Meeting of the Association of American Geographers;" "Geographical Record."

Journal of Geography for March; University of Wisconsin, Madison; $1.00 per year, 15 cents a copy: "An Experiment in Fourth Grade Geography," Mary E. Kelton and Caroline W. Hotchkiss; "The Coral Reefs of the Hawaiian Islands," Vaughan Mac Caughey; "How Library Work, Field Work and Laboratory Work May be Made Mutually Supplemental," H. D. Grose; "Man's Completion of Nature's Supremest Effort on the Great Plains," Charles Keyes; "A Few Suggestions on Field Trip Work," Loulie C. Kelley; "Floods and Famine in China," D. W. Mead; "Geographical Notes."

Mathematical Gazette for December; G. Bell & Sons, Portugal St., Kingsway, London; 6 nos, 9 s. per year, 2 s. 6 d. a copy; "Report on the Teaching of the Multiplication of Decimals," G. W. Palmer; "The Bordered Antilogarithm Table," Prof. G. H. Bryan and T. G. Creak; "Suggestions for Notation and Printing;" "Mathematical Notes."

Nature Study Review for February; Ithaca, New York; $1.00 per year, 15 cents a copy: "The Training of Teachers for Nature Study," R. E. Wager; "A Migration of Beetles," R. A. Sell; "Nature Study and the Common Forms of Animal Life—III," R. A. Shufeldt; "An Adventure," Louise Ravens; "A Few Fish Freaks," G. T. K. Norton; "A List of Teachers of Nature Study," The Editor; "Control of Flies as a Nature-Study Problem," C. F. Hodge.

Popular Astronomy for March: Northfield, Minn.; $3.50 per year, 35 cents a copy; "The Observatory of La Plata," W. J. Hussey; "The History of the Discovery of the Solar Spots" (Continued), Walter M. Mitchell; "Jupiter—The Solar King," George A. Russ; "Origin of Meteors," Col W. F. Badgley; "Transits of Mercury and Venus," William H. Cassell; "Observations of Jupiter—Apparition of 1914," A. Thos. G. Apple; "The Planet Mercury," Bernard Thomas.

Psychological Clinic for February; Woodland Ave. and 36th Street, Philadelphia; $1.50 per year, 20 cents a copy: "A Study of the Fernald Form-Board," Leo Bruckner and Irving King; "An Organized Mental Survey in Philadelphia Special Classes," Norbert J. Melville; "The Social Aspect of an Experiment with Retarded Children," Lillian M. Tobin.

School World for February; Macmillan and Co., St. Martin St., London, W. C.; 7 s. 6 d. per year; "Intensive Work in Science at the Public Schools in Relation to the Medical Curriculum," Sir William Osler; "German Schools and the War." Thomas F. A. Smith; "Education After the War," Sir Oliver Lodge; "Fire Prevention in Schools," A. E. Dunstan; "Scientific Discovery—II.—Natural Selection and Mendelism," R. A. Gregory; "An Experiment in Rural Education."

Unterrichtsblätter für Mathematik und Naturwissenschaft, Nr. 8; *Otto Salle, Ellsholzerstr. 15 Berlin W. 57, Germany; M. 4 per year, 60 Pf. a copy;* "Arbeitsunterrichts," Prof. R. Winderlich; "Die Netzbetrachtung des Dreikants," Dr. P. Suter; "Das Teilbarkeitsgesetz der ganzen Zahlen," Prof. Dr. O. Schröder; "Elementare Betrachtungen zur kaustischen Kurve des sphärischen Spiegels," Dr. E. Magin.

Zeitschrift für Mathematischen und Naturwissenschaftlichen Unterricht Aller Schulgattungen for January; *B. G. Teubner, Leipsic, Germany; 12 numbers, M. 12 per year;* "Die Versuche mit der Atwoodschen Fallmaschine zum Nachweis der Erddrehung," Prof. Dr. W. Brunner; "Ueber Polyeder, deren Netze durch konvexe Polygone gebildet werden," Realgym.-Oberlehrer B. Kerst; "Eine artilleristische Aufgabe," Prof. Dr. E. Haentzschel; "Rein geometrischer Beweis des Satzes, 'Eine Kurve 2. Ordnung ist durch fünf ihrer Punkte eindeutig bestimmt,'" Hans Keferstein; "Bemerkung zu den Dandelinschen Kugeln," E. Magin; "Die kubische Gleichung," H. E. Timerding; "Zur Frage der Einführung der Photogrammetrie in den Schulunterricht," Reismann.

ERRATA.

On page 219 of the March issue, fifth line from the bottom, for G. W. Herrick, read, George W. Hunter.

On page 220, second line from bottom, for W. G. Hunter, read, George W. Hunter.

PROBLEM DEPARTMENT.

By J. O. Hassler,
Englewood High School, Chicago.

Readers of this magazine are invited to propose problems and send solutions of problems in which they are interested. Problems and solutions will be credited to their authors. Address all communications to J. O. Hassler, 2301 W. 110th Place, Chicago.

Algebra.

456. *Proposed by H. Perkins, Battleford High School, Battleford, Sask.*
Find the sum of n terms of the sequence of fractions

$$\frac{1}{1+x}, \frac{2x}{1+x^2}, \frac{4x^3}{1+x^4}, \frac{8x^7}{1+x^8}, \quad . \quad . \quad . \quad . \quad . \quad .$$

I. *Solution by Norman Anning, Chilliwack, B. C.*
Case I, $x = 1$.

$$\begin{aligned} S_1 &= \tfrac{1}{2} &&= 1-\tfrac{1}{2}, \\ S_2 &= \tfrac{1}{2}+1 &&= 2-\tfrac{1}{2}, \\ S_3 &= \tfrac{1}{2}+1+2 &&= 4-\tfrac{1}{2}, \\ S_4 &= \tfrac{1}{2}+1+2+4 &&= 8-\tfrac{1}{2}, \\ &\cdots\cdots\cdots\cdots\cdots\cdots \\ S_n & &&= 2^{n-1}. \end{aligned}$$

Case II, $x \neq 1$.

$$\begin{aligned} \frac{-1}{1-x}+S_1 &= \frac{-1}{1-x}+\frac{1}{1+x} = \frac{-2x}{1-x^2}, \\ \frac{-1}{1-x}+S_2 &= \frac{-2x}{1-x^2}+\frac{2x}{1+x^2} = \frac{-4x^3}{1-x^4}, \\ \frac{-1}{1-x}+S_3 &= \frac{-4x^3}{1-x^4}+\frac{4x^3}{1+x^4} = \frac{-8x^7}{1-x^8}, \end{aligned}$$

. . . . . .

By induction,

$$S_n = \frac{1}{1-x} - \frac{2^n \cdot x^{2^n}}{1-x^{2^n}}.$$

II. *Solution by Elmer Schuyler, Bay Ridge High School, Brooklyn.*
Let

$$\frac{dV}{dx} = S(\text{um}) = \frac{1}{1+x} + \frac{2x}{1+x^2} + \frac{4x^3}{1+x^4} \quad . \quad . \quad .$$

then

$$\begin{aligned} V &= \log(1+x)+\log(1+x^2)+\log(1+x^4)+ \cdots +\log(1+x^{2^{n-1}}) \\ &= \log(1+x+x^2+x^3+ \cdots +x^{2^n-1}), \\ &= \log(1-x^{2^n})-\log(1-x). \\ S &= \frac{-2^n x^{2^n}}{1-x^{2^n}} + \frac{1}{1-x}. \end{aligned}$$

457. *Proposed by Nelson L. Roray, Metuchen, New Jersey.*
Jones settled an annuity upon his three daughters to be divided in the same ratio as their ages. At the first payment the eldest was entitled to one-half the annuity. When the sixth payment was made Martha received one dollar less than she had the first year, Phoebe one-seventh less than the first year and Mary twice as much. What was the amount of the annuity?—From a recent examination paper.

I. *Solution by F. M. Phillips, Central College, Pella, Iowa.*

Let a, b, and $a+b$ represent the ages in order, when the first annuity is paid, and let x equal the amount by which each age is multiplied to get the share of each of the annuity. Then the share of each is ax, bx, and $(a+b)x$, and the total annuity is $2x(a+b)$. When the sixth payment is made, each is five years older, or $a+5$, $b+5$, and $a+b+5$, hence the following equations:

$$\frac{(a+5)2x(a+b)}{2a+2b+15} = 2ax, \tag{1}$$

$$\frac{(b+5)2x(a+b)}{2a+2b+15} = bx-1, \tag{2}$$

$$\frac{(a+b+5)2x(a+b)}{2a+2b+15} = \frac{6(a+b)x}{7}, \tag{3}$$

Solve (1) and (3) for a and b. We have from (3)

$$7a+7b+35 = 6a+6b+45,$$

$$a+b = 10. \tag{4}$$

We have from (1)

$$a^2+5a+ab+5b = 2a^2+2ab+15a,$$

$$a^2+10a+ab = 5b. \tag{5}$$

From (4) and (5) we obtain $a = 2$ and $b = 8$. Substituting these values in (2), we obtain $x = 1\frac{3}{4}$. Then

$ax+bx+(a+b)x = \$35$, the amount of the annuity.

II. *Solution by the proposer.*

[This was the "second solution" by the proposer, the first being much like solution I.—Editor.]

The following solution assumes the term "age" is an integer.

Let x = Phoebe's age.

y = Martha's age,

z = Mary's age.

Then

$$\frac{2z}{x+y+z} = \frac{z+5}{x+y+z+15}.$$

Hence, we must find a fraction whose numerator increased by 5 and whose denominator increased by 15 form the terms of a fraction which is twice the original fraction.

$$\frac{2a}{b} = \frac{a+5}{b+15} \qquad \therefore \quad a = \frac{5b}{b+30}.$$

If $a = 1$, b is not integral; $a = 2$, $b = 20$; $a = 3$, $b = 45$; $a = 4$, $b = 120$. Other values of a make b negative.

$\therefore$ $\frac{2}{20}$, $\frac{3}{45}$ and $\frac{4}{120}$ satisfy the conditions.

Hence, Mary is 2, 3, or 4, according as the sum of the ages is 20, 45, or 120. Phoebe's age follows from

$$\frac{x+5}{20+15} = \frac{6}{7} \cdot \frac{x}{20}, \qquad \therefore \quad x = 10;$$

$$\frac{x+5}{45+15} = \frac{6}{7} \cdot \frac{x}{45}, \qquad \therefore \quad x = 35;$$

$$\frac{x+5}{120+15} = \frac{6}{7} \cdot \frac{x}{120}, \qquad \therefore \quad x \text{ is negative.}$$

The ages are: Mary, 2, or 3; Martha, 8, or 7; Phoebe, 10, or 35

Let P = annuity. Then

$$\frac{8}{20}\,\mathrm{P} = \frac{13}{36}\,\mathrm{P}+1, \qquad \therefore \quad \mathrm{P} = 35.$$

$$\frac{7}{45}P = \frac{12}{60}P+1, \qquad \therefore P \text{ is negative.}$$

Hence the ages that give positive results are 2, 8 and 10, and the annuity is $35.

Editor's Note.

One of the contributors made a slight error by interpreting "the sixth payment" to mean six years from the first payment and secured the same annuity ($35), but with different ages. This suggests to the editor a more general statement of the problem. Instead of "the sixth payment" the problem might read "a subsequent payment" without changing the result as to annuity. Suppose the nth payment is considered. By the method of solution I, it is found that the annuity is $35 and the ages at first payment are $2(n-1)$, $\frac{8}{5}(n-1)$ and $\frac{7}{5}(n-1)$, integral ages occurring when $n = 6, 11, 16, \ldots$.

Geometry.

458. *Proposed by Marie Brown, St. Louis, Mo.*

Place a six-inch sphere in the corner of a room, tangent to the three sides. What is the size of the sphere that may be placed behind it tangent to it and the three sides?

I. *Solution by William W. Johnson, Cleveland, Ohio.*

Let R and r denote the radius of the large and small sphere, respectively. Then, the three edges of the room are a system of coordinate axes, the coordinates of the center of the large sphere are R, R, R, and the coordinates of the center of the small sphere are r, r, r. Therefore, the square of the distance between the centers of the spheres is

$$(R-r)^2+(R-r)^2+(R-r)^2 = 3(R-r)^2.$$

But the distance between the centers is $R+r$.

Hence, we have

$$3(R-r)^2 = (R+r)^2.$$

Solving this equation for r, we get

$$r = R(2\pm\sqrt{3}).$$

Then, the radius of the small sphere is

$$r = R(2-\sqrt{3}).$$

Whence, $r = 0.2679492R$.

But R = 3 inches. Hence, $r = 0.80385$; and the diameter of the small sphere is 1.6077 inches.

II. *Solution by Violet Grinols, student South Dakota State College, Brookings, S. D.*

Let 0 be the center of the sphere having a diameter of six inches, and P the center of the sphere placed behind the larger sphere. Then if A is the corner of the room, $AO = 3\sqrt{3}$, and $AP = r\sqrt{3}$. Let B be the point of tangency of the two spheres. Then $AB = 3\sqrt{3}-3 = 3(\sqrt{3}-1) = r\sqrt{3}+r$. Therefore r, the radius of the smaller sphere, equals .804 inches.

III. *Solution by R. S. Beardsley, Englewood High School, Chicago.*

Let AE be a line drawn from the corner of the room through the center of the six inch sphere to E, on the surface; let C be the point of tangency of the two spheres; BC, the diameter of the small sphere. CE is the diameter of the six inch sphere. Then

$$\frac{AE}{CE} = \frac{AC}{BC},$$

$$\frac{3(\sqrt{3}+1)}{6} = \frac{3(\sqrt{3}-1)}{BC}, \text{ from which}$$

$$BC = 3(4-2\sqrt{3}) = 1.6077 \cdots$$

IV. *Solution by H. H. Seidell, St. Louis, Mo.*

If we consider the sphere to which the given six-inch sphere is tangent internally as satisfying the conditions, there are two solutions, as follows:

The distance from the corner of the room to the center of the given sphere is the diagonal of a cube whose edge is 3 inches; distance $= 3\sqrt{3}$ inches.

The distance to the concave surface is $3(\sqrt{3}-1)$.

The distance to the convex surface is $3(\sqrt{3}+1)$.

If r be the radius of the smaller required sphere and R, the larger required sphere, then

$3(\sqrt{3}+1) : 3(\sqrt{3}-1) :: 3 : r$, from which $r = .804$.

$3(\sqrt{3}+1) : 3(\sqrt{3}-1) :: R : 3$, from which $R = 11.196$.

V. *A further result by Shungo Furni, Selma, California.*

If R (instead of 3) be the radius of the given sphere, the radius of the next sphere is $R(2-\sqrt{3})$; of the third sphere, $R(2-\sqrt{3})^2$; of the nth sphere $R(2-\sqrt{3})^{n-1}$.

459. *Proposed by Norman Anning, Chilliwack, B. C.*

The sides, in order, of a cyclic pentagon, 4, 6, 4, 6, 4. Show that the diagonals are integral.

I. *Solution by the Proposer.*

Let ABCDE be the cyclic pentagon in which

$$\overline{AB} = \overline{CD} = \overline{EA} = 4, \qquad \overline{BC} = \overline{DE} = 6.$$

We have $\overline{AC} = \overline{BD} = \overline{CE} = \overline{DA} \neq \overline{EB}$.

Let $\overline{AC} = x$ and $\overline{EB} = y$.

Applying Ptolemy's theorem to ABCD,

$$x^2 = 6x+16,$$

$$x = 8, -2.$$

Dropping the trivial solution, $x = -2$, we have

$$\overline{AC} = \overline{BD} = \overline{CE} = \overline{DA} = 8.$$

Applying Ptolemy's theorem to ABCE,

$$8y = 32+24.$$

$$\overline{EB} = y = 7.$$

II. *Solution by Elmer Schuyler, Brooklyn.*

Let O be the center of the circle and let ABCDEA be the pentagon, in which $\overline{AB} = \overline{CD} = \overline{EA} = 4$ and $\overline{BC} = \overline{DE} = 6$.

Denote the angle AOB by 4ϕ, then the diagonal BE is bisected by AO and $\angle EAO = 90^\circ - 2\phi$; also $\angle ABC = 90^\circ + \phi$.

Now,

$$\frac{2}{r} = \sin 2\phi, \text{ and } \frac{3}{r} = \cos 3\phi.$$

Consequently

$$\frac{\cos 3\phi}{\sin 2\phi} = \frac{3}{2}, \text{ and } 4\sin^2\phi + 3\sin\phi - 1 = 0.$$

Hence $\sin\phi = \frac{1}{4}$.

$$\overline{BE} = 8(1-2\sin^2\phi) = 8(1-\tfrac{2}{16}) = 7,$$

and $4^2+6^2-2\cdot 4\cdot 6\cos(90^\circ+\phi) = \overline{AC}^2$,

or $16+36+48(\frac{1}{4}) = AC^2$.

$$\therefore \qquad \overline{AC} = 8.$$

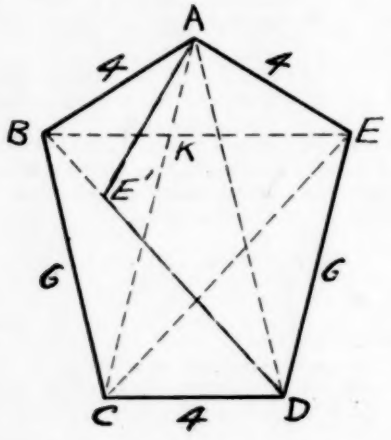
III. *Solution by Shungo Furni, Selma, California.*

Let ABCDE be the cyclic pentagon in which

$$\overline{AB} = \overline{CD} = \overline{EA} = 4, \qquad \overline{BC} = \overline{DE} = 6.$$

We have $\overline{AC} = \overline{BD} = \overline{CE} = \overline{DA} \neq \overline{BE}$.

Bring E to E′ on BD and let ED coincide with E′D. $\angle ADB = \angle ADE$. $AE = AE' = AB$. Then, Δ ABE′ is isosceles. ΔACD is also isosceles; and $\angle ABE' = \angle ACD$, (being inscribed in equal arc). The two triangles being similar, we have



$$\frac{\overline{BE'}}{\overline{CD}} = \frac{\overline{AB}}{\overline{BE'}+E'D} \text{ or } \frac{\overline{BE'}}{4} = \frac{4}{\overline{BE'}+6}, \text{ or } \overline{BE'^2}+6\overline{BE'}-16=0.$$

$$\overline{BE'} = 2, \text{ or } -8.$$

Considering only the positive value, we have

$$\overline{BD} = 6+2 = 8, \qquad \text{which is integral.}$$

In ΔABE, AB = AE and the triangle is isosceles.

In the triangles AEK and ABE′, AB = AE, $\angle ABD = \angle EAC$, $\angle AEB = \angle CAD = \angle BAE'$. Hence the triangles are congruent.

Then $\overline{AK} = \overline{BE'} = 2$, $\overline{EK} = 4$, $\overline{KC} = \overline{E'D} = 6$. But

$$\frac{\overline{BK}}{\overline{AK}} = \frac{\overline{KC}}{\overline{KE}}. \text{ Then } \frac{\overline{BK}}{2} = \frac{6}{4}, \text{ and } \overline{BK} = 3.$$

$$\overline{BE} = 3+4 = 7, \qquad \text{which is integral.}$$

460. *Proposed by A. E. Jeffrey, Goshen (Ind.) High School.*

AB is the diameter of a semicircle and at any point C on AB the perpendicular CD is erected to AB meeting the arc at D. Also on AC and BC as diameters circles are drawn.

The two circles which can be drawn, each tangent to two of the semicircles and tangent to CD are equal.

I. *Solution by C. A. Hahn, Westerville, Ohio; F. N. Phillips, Pella, Iowa; Florence Pinney, Sturgeon Bay, Wisconsin. (Notation by C. A. Hahn).*

O, M, M_1, N, N_1, are the centers, respectively, of the circles on AB, BC, AC and the unknown circles. NH and N_1H_1 are drawn $\perp$ to AB.

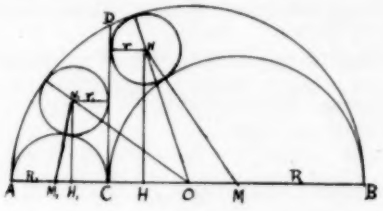
Referring to the notation of the figure, since $OA = R+R_1$, we have

$$\overline{OH} = R-R_1-r, \quad \overline{ON} = R+R_1-r,$$
$$\overline{MN} = R+r, \quad \overline{MH} = R-r.$$

In the triangles NMH and NOH, we have

$$NH^2 = (R+r)^2-(R-r)^2 = (R+R_1-r)^2-(R-R_1-r)^2.$$

Solving for r,



$$r = \frac{RR_1}{R+R_1}.$$

In a similar manner, using triangles $N_1M_1H_1$ and N_1OH_1, we have

$$r_1 = \frac{R_1R}{R_1+R}.$$
$$\therefore \quad r = r_1.$$

II. *Solution by Nelson L. Roray and Norman Anning.*

Let O be the mid-point of AB, O′ the mid-point of AC, O″ the center of the circle tangent to the semicircle O′, semicircle O and to CD.

Let $R = \frac{1}{2}\overline{AB}$, $\rho = \frac{1}{2}\overline{AC}$ and x the radius of the circle O″.

Then in $\Delta O'O''O$, $OO'' = R-x$, $O'O = R-\rho$, $O'O'' = \rho+x$ and $\rho-x$ = the projection of $\rho+x$ upon $R-\rho$.

$$(R-x)^2 = (R-\rho)^2+(\rho+x)^2-2(R-\rho)(\rho-x).$$
$$x = \frac{4R\rho-4\rho^2}{4R}$$
$$= \frac{2\rho(2R-2\rho)}{4R}$$
$$= \frac{\overline{CD}^2}{4R}$$

In the same manner the radius of the other circle is shown to be $\frac{\overline{CD}^2}{4R}$.

III. *A further conclusion by Shungo Furni.*

Using D_1, D_2, D_3 as the diameters of the circles on AB, BC and AC, respectively (assuming BC>AC), and D_4 as the diameter of the equal circles, we find

$$D_4 = \frac{D_2D_3}{D_1}, \quad \text{whence} \quad \frac{D_1}{D_2} = \frac{D_3}{D_4}.$$

Hence, *The diameter of the equal circles is a fourth proportional to the diameters of the given circles and is greatest when CD bisects AB. (For $D_2D_3 = \overline{CD}^2$, which is greatest when AC = CB.)*

CREDIT FOR SOLUTIONS.

434, 447, 449. C. Subrahmania. (3)

452. Yeh Chi-Sun.

453. Aaron Freilich, Yeh Chi-Sun. (2)

454. Aaron Freilich.

456. Norman Anning, C. A. Hahn, M. Helen Kelley, F. M. Phillips, Nelson L. Roray, Elmer Schuyler, H. H. Seidell, Edward H. Worthington. (8)

457. Norman Anning, Carrie Mikesell, F. M. Phillips, Nelson L. Roray (2), one incorrect solution. (6)

458. Norman Anning, R. S. Beardsley, Shungo Furni, Violet Grinols, C. A. Hahn, A. E. Jeffrey, William W. Johnson, Clifford H. Nickle, F. M. Phillips, Florence Pinney, Elizabeth Staudinger, H. H. Seidell, I. N. Warner. (13)

459. Norman Anning, Shungo Furni, Elmer Schuyler. (3)

460. Norman Anning, Shungo Furni, C. A. Hahn, Clifford N. Mills, F. M. Phillips, Florence Pinney. (6)

Total number of solutions (43).

PROBLEMS FOR SOLUTION.

Algebra.

471. *Proposed by H. Perkins, Battleford (Saskatchewan) High School.*

If

$$\sqrt[4]{x}+\sqrt[4]{y}+\sqrt[4]{z}=0,$$

prove that

$$[x^2+y^2+z^2-2(yz+zx+xy)]^2=128xyz(x+y+z).$$

472. *Proposed by Elmer Schuyler, Brooklyn.*

If n is even, show that $n(n^2+20)$ is divisible by 48.

(From Hall and Knight's Higher Algebra).

Geometry.

473. *Proposed by Nelson L. Roray, Metuchen, New Jersey.*

ABCD is a parallelogram. On AB take AE, on DC take DF = AE. H is the mid-point of AE, I is the mid-point of FC. M is the median point of ΔAEF, N is the median point of ΔEFC. Prove MN, HI and BD are concurrent.

474. *Proposed by G. I. Hopkins, Manchester (N. H.) High School.*

Two fixed tangents, a_1 and a_2, are drawn to a circle with center O. Any line through O meets a_1 in P_1 and a_2 in P_2. The second tangents through P_1 and P_2 intersect in P. Show that the locus of P is a circle with center O. (From a recent examination paper in elementary geometry.)

475. *Proposed by Elmer Schuyler, Brooklyn.*

Prove, geometrically, that if a and b are the arms of a right triangle and c the hypotenuse, then

$$a+b\leq c\sqrt{2}.$$

PRECIOUS METALS OF COLORADO.

The United States Geological Survey now has available for distribution its annual statement on the production of gold, silver, copper, lead, and zinc in Colorado for 1914. The total value of the output of these metals in Colorado for the year was $33,460,126, of which fifty-nine per cent represented gold.

SCIENCE QUESTIONS.

By Franklin T. Jones,
University School, Cleveland, Ohio.

Readers of School Science and Mathematics *are invited to propose questions for solution—scientific or pedagogical—and to answer questions proposed by others or by themselves. Kindly address all communications to Franklin T. Jones, University School, Cleveland, Ohio.*

Questions and Problems for Solution.

218. *From Morgan & Lyman's Chemistry (The Macmillan Co.)*

Comment on the following:

(a) If a piece of meat is cooked by boiling in 2 hours, how long should it take in a "hay box," or fireless cooker, at an average temperature of perhaps 80°? (From Morgan & Lyman p. 21.)

(b) What kind of change is involved in the *withering* (wilting) of a leaf?

219. *Proposed by O. L. Brauer, Selma Union H. S., Selma, Cal.*

Is there a good illustration of a variable approaching a finite limit not zero? Namely, a physical illustration.

220. *Proposed by R. G. Rupp, Hammond, Ind.*

A piece of iron of density 7.5 floats in mercury (density = 13.5) and is completely covered with water which rests on the top of the mercury. How much of the iron is immersed in the mercury?

Please answer questions numbered 221, and 222 in the succeeding list:

The University of the State of New York High School Physics.

January 19, 1915—9:15 a. m. to 12:15 p. m., only

Write at top of first page of answer paper (a) name of school where you have studied, (b) number of weeks and recitations a week in physics, with the total number of laboratory periods and the length of such periods.

The minimum time requirement is five recitations a week for a school year. A double laboratory period counts in place of one recitation. Laboratory work equivalent to 30 double periods is required.

Answer 10 questions, selecting at least one question from group I, one from group II, two from group III and three from group IV.

Group I—Answer at least one question from this group.

1 How does sound differ from light in respect to (a) the characteristics of the waves [4], (b) the nature of the medium required for transmission [3], (c) the velocity of transmission [3]?

2 By means of a labeled diagram, show approximately the path of a ray of light through a triangular glass prism [5]. What change in the angle of deviation is caused by a decrease in the refracting angle of the prism [5]? [Assume that the incident ray strikes the prism at the same angle in each case.]

221. If a photographic print can be satisfactorily made in 20 seconds when placed 12 inches from a 16 candle power electric lamp, how long will it take to make a print of the same intensity if a 32 candle power lamp is used at a distance of 24 inches? [10]

Group II—Answer at least one question from this group.

4 A cup of hot tea is cooled by ice; describe in detail the temperature changes and the heat exchanges that result. [10] [In the description ignore changes due to radiation or absorption.]

5 A kettle of hot water is heated over a fire. Describe the manner in

which the water next to the bottom of the kettle receives its heat [5]. Explain how the remainder of the water is heated [5].

6 What is meant by a relative humidity of 40% in the air of a schoolroom [6]? If the other conditions remain unchanged, how would the relative humidity of the air of the room be affected by a rise of temperature [4]?

Group III—Answer at least two questions from this group.

7 Describe, using a labeled diagram, a laboratory method of measuring electrical resistance. [10]

8 An electric stove has two heater coils; when these coils are joined in series with each other they use 1.25 amperes on a 110 volt circuit. What is the resistance of each coil [5]? If the coils are joined in parallel on the same circuit, what current will be used [5]?

9 Indicate (a) by a labeled diagram the direction of the current induced in a coil of wire when the north pole of a bar magnet is thrust into the coil [4], (b) by a second diagram the direction of the current induced when the north pole is removed from the coil [4].

Mention a practical application of the principle involved in this experiment. [2]

10 Five 16 candle power incandescent lamps, each having a resistance of 220 ohms when hot, are arranged in parallel on a 110 volt circuit; calculate (a) the total current used by these lamps [5], (b) the watts consumed by each lamp [5].

Group IV—Answer at least three questions from this group.

11 To what do the terms weight and mass as applied to a body refer [6]? Mention a way by which the weight of a body may be changed without altering its mass [4].

12 Make a drawing (vertical cross section), showing a tumbler of water and a tumbler of mercury, with a fine and a coarse capillary glass tube standing in each. Represent the relative levels and the general shapes of the liquid surfaces in the tumblers and the tubes. [10]

13 A weight is supported by two spring balances which form an angle of 90° with each other; one of the balances registers 8 pounds and the other 6 pounds. What is the magnitude of the weight [4]? Represent by diagram the relative magnitudes and directions of the forces involved [6].

14 If a meter stick weighing 160 grams is placed on a knife edge at the 60 centimeter mark, what weight should be fastened at the 100 centimeter mark in order to maintain equilibrium in a horizontal position? [10]

222. An electric motor, having a speed of 1200 revolutions per minute, runs a sewing machine at a speed of 400 revolutions per minute; if the pulley on the motor has a diameter of 1½ inches, what must be the diameter of the pulley on the sewing machine? [10] [Assume that the belt does not slip.]

SMITH COLLEGE ENTRANCE EXAMINATION IN ELEMENTARY CHEMISTRY, SEPTEMBER, 1915.

1. Name four important constituents of the atmosphere. How may the presence of each be shown?

What per cent of the atmosphere is oxygen? How may it be determined?

2. For what purpose have you used the following reaction in the laboratory? Write the equations.

Potassium chlorate and heat.
Sodium hydroxide and sulphuric acid.
Barium chloride and sulphuric acid.
Sodium nitrate and sulphuric acid, conc.
Copper nitrate and sulphuric acid, conc.
Silver nitrate and hydrochloric acid.
Manganese dioxide and hydrochloric acid.

3. How much quicklime can be made from 100 lbs. of limestone? How much carbon dioxide would be given off?

4. How would you prepare and collect four of the following gases: hydrogen, hydrogen sulphide, hydrogen chloride, nitric oxide and ammonia?

5. How does the density of each of the following gases compare with that of oxygen; sulphur dioxide, hydrogen, ammonia and carbon dioxide? Explain how Avogadro's hypothesis may be used in answering this question.

6. Give a method of distinguishing between the members of the following pairs:

Hydrogen sulphide and sulphur dioxide.
Hydrogen chloride and chlorine.
Sulphurous acid and sulphuric acid.
Sodium chloride and sodium carbonate.
Sodium chloride and ammonium chloride.

7. Give a test which will distinguish between carbon monoxide and carbon dioxide. How may each of these gases be prepared?

Name two ways in which carbon dioxide is used practically.

8. Discuss two of the following topics: soap making; mordants; hard water; glass.

9. Name the three most important halogens. How do they compare in chemical activity? How can one be made to replace another in a potassium salt?

10. What is the "raw material" from which each of the following is manufactured: "illuminating gas; washing soda; kerosene; coke; sulphuric acid.

Solutions and Answers.

189. *Proposed by A. Haven Smith, Riverside, Cal.*

What is the numerical value of the heat of vaporization of water at temperatures other than 100°C.?

Answer by O. L. Brauer, Selma, Cal.

Also solved by O. D. Parsons, Yonkers High School, N. Y.

If experimental data only is desired, Henning, in Ann. d. Phys. [4] 21: 849 (1906) found that the heat of vaporization of water drops off .63 per degree as the temperature falls below 100°C.

Theoretical Discussion:

The decrease of total energy, E, in the evaporation of 1 gram of water is equal to the external work, due to polymerization of H_2O molecules in water.

202. (a) Answer is 136 cm. (b) 85 vibrations per sec.

203. (a) Answer is 127—°C. (b) Answer is 194+°C. (c) Preheating helps materially.

206. Answer is 2—liters.

207. Answer is 23.03.

208. *Proposed by Maxwell Sosin, Perth Amboy, N. J.*

Sound travels, approximately, 1 mile in 5 seconds. Suppose a man on a hydroplane above some vast body of water, traveling at that rate, fired a gun. Since he is moving with the same velocity as the report of the gun, it seems that he would not cease to hear the sound.

Answer by J. P. Drake, State Normal School, Emporia, Kan.

If the conditions were as named in this problem he would not hear the gun if held above, back to the right or to the left. If held close to the ear he would not get vibrations enough to hear a sound as the ear would go at the same rate as the sound wave. If he held the gun in front of him he would get a high pitched sound for an instant and then it would be quiet.

209. *Proposed by W. L. Baughman, East St. Louis, Ill.*

How much should the outer rail of a 5-foot track be raised above the level of the inner rail in order that a train may safely run a curve of one-eighth mile radius at the rate of 30 miles an hour?

Solved by J. P. Drake.

The tangent of the angle which the rails will make with the horizontal in order to equalize the pressure on the rails will be

$$\frac{\frac{mv^2}{r}}{mg} = \frac{v^2}{rg} = .091 = \tan\phi; \text{ or the angle } \phi = 5°.2+$$

This gives a value of 5.5+ inches that the outside rail will have to be raised.

A NEW SCIENTIFIC JOURNAL.

There has recently come to our desk No. 1, Vol. 1, of the Tsing Hua Journal, which is a continuation of the Tsing Hua Monthly. This Journal is published in Pekin, and we welcome it to the long list of journals which are doing such effective work in spreading the gospel of right science and mathematics teaching throughout the world. The Tsing Hua Journal will be published one month in English and the alternate month in Chinese. The first part of each issue will be devoted to a record of things done in Tsing Hua College, and the latter part will be given over to the discussion of miscellaneous subjects. Matters of educational interest throughout the empire of China will be treated in such a way as to give the readers of this new Journal a comprehensive idea of what things educational are being done in that country.

ABOLISH THE FAHRENHEIT THERMOMETER.

There has recently been introduced into the House of Representatives by Congressman Albert Johnson of the third district of Washington, Bill 528, which has for its purpose the discontinuance of the use of the Fahrenheit thermometer in government publications. Readers of this Journal will undoubtedly be a unit in using their influence to have this bill passed by the present Congress. There is no well-founded reason except that of common use, for the continuance of the Fahrenheit thermometer in this country. All of the scientific investigations where temperature is considered, are made with a Centigrade scale, which is very convenient to use. It would seem that science instructors the country over should use their influence in order that this bill may receive favorable consideration. Many science men and associations have already approved of the step. Readers of this journal can assist in bringing about this legislation by writing to their congressmen and asking them to vote favorably on it when the bill comes up for action.

SOUTHERN CALIFORNIA SCIENCE AND MATHEMATICS ASSOCIATION.

The fifteenth regular semiannual meeting of the Southern California Science and Mathematics Association was held at the Los Angeles High School, January 22, 1916.

The general morning session was called to order at 10:15 by the President, Mabel B. Peirson, of the Pasadena High School, in the auditorium of the high school. About seventy-five were present.

A number of moving-picture films illustrating industrial problems were shown. The meeting then adjourned to the physics lecture room where Mr. Robert T. Hill, of the United States Geological Survey, delivered a very instructive address on "The Geology and Geography of Southern Cailfornia." Much of the material presented by Mr. Hill has not yet appeared in print but will later be embodied in a publication.

After an enjoyable luncheon at the high school cafeteria some time was spent in an inspection of the laboratories.

The afternoon was given over to meetings of the Mathematics and Science Sections.

The Mathematics Section listened to an address at 1:30 p. m. on "Examples of Applications of Mathematics to Engineering Problems," by Prof. A. W. Nye, Head of Electrical Engineering Department, University of Southern California, followed by a discussion.

The Science Section was addressed at 1:30 p. m. on "Feeble-mindedness: Causes, Prevention and Cure," by Ernest Hoag, M. D. Films showing movements of the amoeba believed to cause pyorrhea were shown by H. Page Bailey.

Following the section meetings a number of the latest-improved, moving-picture machines for class-room use were demonstrated.

The meeting was voted a very enjoyable and profitable one by all present.

C. M. WESTCOTT,
Secretary.

THE NEW JERSEY SCIENCE TEACHERS' ASSOCIATION.

The twentieth regular meeting of this association was held in the Camden High School on Saturday, February 19th. The forenoon was devoted to a visit to that very interesting plant of the Welsbach Mantle Factory at Gloucester City. The journey through the works occupied about three hours. The members of the association were able to examine the complete process of the manufacture of gas mantles, starting with the knitting of the fabric, and watching the processes of the impregnation, sewing, burning out, and dipping. The chemical department was of especial interest, as the visitors learned something about how thorium is extracted for use as a lighting fluid. Attention was called also to the reclamation of waste ammonia liquors, etc., coming from the various operations in the plant. This excursion was of the very highest grade from an educational point of view, and it impressed upon those who participated in the trip, the necessity of more thoroughly keeping in touch with the great manufacturing plants of the country.

Luncheon was served at fifty cents per plate at the Garden Hotel, Camden. After the luncheon the association adjourned to the High School, where the members listened to an address of Dr. Robert H. Bradbury of the Southern High School, Philadelphia, on "The Future of Chemistry in the High School." Dr. Bradbury has been a frequent contributor to this journal. Following this address was one of Dr. James E. Peabody of the Morris High School, New York City, on "Continuity and Cooperation Rather Than Competition in Science Teaching." Dr. Peabody has also frequently contributed to this journal, and he is now chairman of the science section of the N. E. A., and also chairman of the committee that is preparing a science syllabus for the first two years of high school.

This twentieth annual meeting was one of the most interesting that the association has ever held, and the members are determined to make the future meetings of even greater interest.

DARTMOUTH COLLEGE SUMMER SESSION.

In the next summer session of Dartmouth College, extending from July 5 to August 16, 1916, the following courses in mathematics will be given: by Professor J. W. Young, The Reorganization of Secondary School Mathematics; by Professor E. G. Bill, (1) Plane Analytic Geometry, (2) Projective Geometry. The course by Professor Young will include a critical examination of the grounds on which the reorganization of secondary-school courses in mathematics is demanded, and a comprehensive examination of the fundamental concepts and methods of mathematics, with reference to their availability and value as secondary-school material.

STUDY OF CASTINGS OF ZINC BRONZE.

An investigation of the various foundry operations influencing the properties of castings of one of the most generally used commercial alloys, known as government bronze, having the composition 88 per cent copper, 10 per cent tin and 2 per cent zinc, has been completed by the Bureau of Standards, Department of Commerce, and the results have just been published in Technologic Paper No. 59. The quality of metal castings is usually determined by measuring the properties of a test specimen cast from the particular metal. The investigation included a study of the effects of temperature of castings, methods of casting, moulding, etc., kind of sand, heat treatment, and the effects of similar factors upon the resulting mechanical properties.

A microscopic examination of the fractured test specimens was also made, which showed that the most common source of weakness is the occurrence of oxides within the metal. Such oxides appear frequently as thin films throughout otherwise sound metal, producing a condition of brittleness and low ductility.—*Department of Commerce Bulletin.*

CLASSROOM SAYINGS.

SCIENTIFIC ACCURACY: A certain professor in a New England scientific school put this question upon the board in an examination of his class:

"What steps would you take to obtain the height of a great modern skyscraper by use of an aneroid barometer?"

One student answered:

"To obtain the most accurate results from the use of this instrument in the circumstances, I would tie the aneroid barometer to a string, lower it from the roof and then measure the string."

Q.: Of what does the scientific name of a plant consist?
Ans.: The scientific name of a plant is anything that is green.

Q.: Define photosynthesis.
Ans.: The protoplasm in photosynthesis is the process whereby the movements of the leaf are carried on.

Q.: What is the use of stomates?
Ans.: Stomates extricate the gas exchanges.

Q.: Define a gametangium. (Questions were read to pupils and they copied them.)
Ans.: A gametango is a case of active cells.

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Q.: What is the meaning of photosynthesis?
Ans.: Photosynthesis means, "Making in the dark."

Q.: Name two kinds of energy.
Ans.: Two kinds of energy are latent and unlatent.

Q.: Why is it that the air pressure does not crush your body?
Ans.: The reason that our bodys hold up at this pressure is because that nobody seems to die on account of it.

Q.: Give an example of eroding by water. Could it have been prevented? If so, how?
Ans.: Grand Canyon of Arizona is an example of erosion. It might of been prevented laying a pipe for the water to go through.

Q.: How much heat does 1 gallon of water absorb when heated 1 degree?
Ans.: One gallon.

Q.: Name three natural convection currents.
Ans.: The sun, and heating a room by a stove.

Q.: How are moments of force calculated?
Ans.: By looking at a clock.

Q.: Give an example of stable equilibrium.
Ans.: A horse in a stable.

Q.: Define motion.
Ans.: Anything that moves.

Q.: What is force?
Ans.: Force is speed of anything.

Q.: What is the effect of heat on gases?
Ans.: Heat makes gas burn; cold puts it out. If you have a match you can light the gas; if you have no match you can't make it burn.

BOOKS RECEIVED.

A Practical Elementary Chemistry, by B. W. McFarland, New Haven High School. Pages xvi+462. 14x20 cm. Cloth. 1915. $1.25. Charles Scribner's Sons, New York.

Fundamental Sources of Efficiency, by Fletcher Durell, Lawrenceville School. 368 pages. 15.5x23 cm. Cloth. 1914. $2.65 net. J. B. Lippincott Company, Philadelphia.

Constructive Geometry, by E. R. Hedrick, University of Missouri. Pages vi+75. 20x26.5 cm. Paper. 1916. The Macmillan Company, New York.

BOOK REVIEWS.

Food and Nutrition, by Isabel Bevier, University of Illinois. 80 pages. 13x20 cm. Cloth. 1915. $1.00 net. Whitcomb and Barrows, Boston.

A splendid little text which is now appearing in its third edition. It has for its fundamental thought the devising of new experiments which will have a direct application to the principles governing the selection and preparation of food. It will at the same time materially assist students of Home Economics in becoming more familiar with the problems of food and nutrition. There are in the book 106 splendid experiments, nearly every one of which closes with a list of excellent questions bearing upon the experiment. There is also a bibliography of three or four pages. C. H. S.

Robert of Chester's Latin Translation of the Algebra of Al-Khowarizmi, with an Introduction, Critical Notes, and an English Version, by Louis Charles Karpinski, University of Michigan. Pages vii+164. 18x27 cm. Paper covers. $2.00. 1915. The Macmillan Company, New York.

The algebra of Al-Khowarizmi has an important place in the history of mathematics, since most of the early medieval works in algebra in Europe were based on it. This English version of Robert of Chester's Latin translation is a valuable contribution to the history of mathematics and to the literature that teachers of secondary mathematics may find of great use in their classroom work. In the introduction of sixty-two pages, Professor Karpinski gives a brief account of algebraic analysis before Al-Khowarizmi, what little is known of the author and his writings, Robert of Chester and other translators of Arabic manuscripts, the influence of Al-Khowarizmi's algebra upon the development of mathematics, and the manuscripts of Robert of Chester's translation. This introduction gives one a vivid perception of the growth of algebraic ideas among various nations in early times; and the author's conclusion that, "Algebra is not, as often assumed, an artificial effort of human ingenuity, but rather the natural expression of man's interest in the numerical side of the universe of thought," is of much interest.

The Latin text is given on the even pages and the English version on the odd pages, so that the reader if he chooses can examine Robert of Chester's own words. But the chief interest for most readers will probably lie in the old Arabic algebra itself. It will take a little time to recognize the familiar facts of algebra in their strange garb. "A square is equal to 5 roots. The root of the square then is 5, and 25 forms its square which, of course, equals 5 of its roots." This is the Arabic mathematician's way of saying, "$x^2 = 5x$, $x = 5$, $x^2 = 25$." After giving the algebraic solution of some quadratic equations he gives two different geometrical proofs of his rule, and thus shows the advantage of unified mathematics. There are four large photographic reproductions of pages of the Latin manuscripts. H. E. C.

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Plane and Solid Geometry (*also separately*)	**1.30**
Plane and Spherical Trigonometry, with Tables (*also separately and without tables*)	**1.35**

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Plane and Solid Geometry, by Webster Wells and W. W. Hart. Pages viii+467. 13x18 cm. 1915. D. C. Heath & Co., New York.

The *Plane Geometry* was reviewed in a recent number of this journal. The *Solid Geometry* is well planned to keep the attention of pupils on geometrical notions. Nearly all of the theorems are followed by some geometrical exercises based on the theorem, and there is a rather small number of numerical exercises. Almost no connection is made with algebra. The less important theorems are grouped at the end of each book under "Supplementary Topics." Under the definition of a prismatoid solids can be constructed whose volume is not correctly given by the prismatoid formula. No doubt many teachers will find this a satisfactory textbook. H. E. C.

Selection and Preparation of Food. A Laboratory Manual. By Isabel Bevier and Anna R. Van Meter. 110 pages. 13x19.5 cm. Cloth. 1915. 75 cents net. Whitcomb & Barrows, Boston.

This is the third edition of this splendid little book. It is one of the best manuals on Home Economics published, and one which all Home Economics instructors should possess. It is filled with a fund of information which will render the teacher's work much more easy and efficient. One hundred and ninety-three experiments are given, and all are of a practical nature, with many helpful suggestions. A splendid index is given. Mechanically the volume is well made, and is printed on uncalendared paper, which largely does away with the glaring reflection of light. C. H. S.

The Adolescent Period. By Louis Starr, College of Physicians, Philadelphia. Pages vii+211. 13x19 cm. Cloth. 1915. $1.00 net. P. Blakiston's Son & Co., Philadelphia.

This book has been prepared fundamentally to give its readers a good outline of the psychological changes which may be expected in the period

of life between the end of childhood and the beginning of the adult age, and to point out some of the methods of management which should be considered in order to overcome the dangers of the trying years of the adolescent period and bring the young child into a healthy and useful maturity. The book is not an exhaustive treatise, but gives many of the fundamental facts in an open and convincing way. It is a book that all parents would do well to read. It deserves a wide circulation. C. H. S.

Teachers' Handbook to accompany Foundations of Chemistry, by A. A. Blanchard and F. B. Wade. Pages 110. 5x8 cm.

This is an indispensable handbook for every teacher who uses the author's textbook.

Besides the answers to problems and review questions, it contains much explanation of chemical theory and commercial applications of chemistry. A number of quotations from the original papers of men who made great discoveries in chemistry are given. C. M. T.

The Book of Stars, by A. F. Collins. Pages xv+230. 13x19.5 cm. Cloth. 1915. D. Appleton & Co., New York.

A book prepared and written primarily to give to boy life, and especially to boy scouts, a knowledge of the stars and heavens. It is put up in simple language, such that the young fellow can clearly understand what the author is driving at. It makes interesting reading. It is illustrated by 186 cuts. The matter is discussed under the head of twelve chapters, and the apparatus that is used in the study of the stars as far as this book is concerned, is of the simplest kind. It is a volume that every scout master should possess. Several pages of the appendix are devoted to the definition of words used in the text. There is a splendid index. Altogether the book is worthy of a wide circulation. C. H. S.

Engineering as a Career, by F. H. Newell, University of Illinois, and C. E. Drayer. Pages xii+214. 13x19 cm. Cloth. 1915. $1.00 net D. Van Nostrand Co., New York.

This is a book which young men who have a bent toward an engineering career of one phase or another should get and read. At the same time, parents of such boys should become familiar with the book, as there are matters discussed therein which will be of vital importance to both father and son in helping them to determine the kind of profession the young man shall engage in. All boys who have a leaning toward engineering will not necessarily make good engineers, and if the future of the engineer can be more clearly brought before the young man's mind, he may be better able to decide upon his life work, and by a closer scrutiny of some of the things which are bound to happen in the life of an engineer he may save himself much trouble later on. This is a book of magnificent ideas, and it treats of almost all phases of engineering as a career. Various departments of the work are discussed by engineers and men who are past masters in the business. It is a volume which the writer of this little paragraph has carefully studied with his older son, who has ideas which are fast leading him to a time when he will undoubtedly decide upon an engineering career, and from this personal experience the writer is advising all men in a similar situation to get and read the book. C. H. S.

Commerce and Industry, by J. Russell Smith, University of Pennsylvania. Pages vi+596. Cloth. 1916. Henry Holt & Co., New York.

A book which has been written and put on the market for the purpose of bringing all classes of people to a fuller realization of the intimate connection which exists between the production of food stuffs and raw material and the concerns which take the raw material and convert it into

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a condition for use by the ultimate consumer. The volume attempts to explain how the industries of man are more or less determined by his environment, how the climate affects man, how the soil upon which he lives furnishes him materials for shelter, wearing apparel, and food to eat. The major portion of the book is devoted to a discussion of the conditions as they exist in the United States. Latin America receives her due proportion, and the Orient comes in with its due share. The trade routes of the world are thoroughly discussed and outlined by charts. The text is profusely illustrated by original photographs, drawings, and charts, of which there are 295. The major paragraphs all begin with bold-faced type, and at the end of practically every chapter there are questions appended. The volume is written in a most interesting and fascinating manner. Scholar and layman will be equally interested in perusing its pages. There are appended several tables of statistics of great value. The index of 14 pages is very complete. It is a book which every person interested in the welfare of his country should purchase, read and study. C. H. S.

A Brief Course in Algebra, by Raymond E. Manchester, Professor of Mathematics, State Normal School, Oshkosh, Wis. Pages 198. 13x18 cm. 1915. C. W. Bardeen, Syracuse, N. Y.

This book is planned to give a well-established notion of algebra through quadratics in a course of twenty weeks, and seems to be well thought out and presented with great clearness. No doubt the teacher will find time to make some additions to the short lists of problems, as recommended by the author. This work is intended to be a course in generalized arithmetic to meet the needs of the ninety per cent of pupils who expect to leave school either during the high-school course or at its close. The discussion of zero exponents should be revised. H. E. C.

Historical Introduction to Mathematical Literature, by G. A. Miller, Professor of Mathematics in the University of Illinois. Pages xiii+302. 13x19 cm. $1.60. 1916. The Macmillan Company, New York.

Many of the recent textbooks in algebra and geometry give brief historical notes, but for the most part these notes consist simply of the names and dates of early mathematicians and a few facts of their lives. If these notes lead pupils and teachers to consult encyclopedias and histories of mathematics for a broader knowledge of the development of mathematics, then much has been accomplished. Since histories of mathematics seem to emphasize the work of ancient and modern mathematicians, the wonderful development of mathematics in the last century is not known or appreciated by many teachers.

The present volume gives one a broad outlook on the field of mathematics, and is rich in references to works accessible to many students. Modern developments and activities have a prominent place. Thus, in the chapter on prominent deceased mathematicians, of the twenty-five biographical sketches only five date back to earlier than the seventeenth century. In the first chapter the changes during the nineteenth century, the developments of the last fifteen years, and the growth of American mathematics are outlined.

Much information concerning mathematical literature in general—journals, monographs, pamphlets, books, and the work of mathematical societies is given in the second chapter. After an illuminating discussion of general historical questions relevant to mathematics in the third chapter the author gives an account in some detail of the fundamental developments in arithmetic, geometry, and algebra covering eighty-seven pages.

Written in semi-popular, lecture style, opening up broad views of the field of mathematics, scholarly, and dependable on questions of historical accuracy, this book is heartily commended to all teachers of mathematics, and should be in every school library. H. E. C.

General Chemistry for Colleges, by Alexander Smith, Professor of Chemistry and Head of the Department, Columbia University. Pages x+662. Size 14.5x20.5x3.5 cm. Numerous illustrations. Cloth. 1916. $2.25. The Century Company.

This new edition of *General Chemistry for Colleges* shows some notable improvements over its very worthy predecessor. The introduction to the subject has been revised and greatly improved. The method of the introductory pages is natural and will serve to introduce the student to a new subject without undue shock. It would indeed perhaps be well if this natural method carried throughout the book. Too often the more businesslike systematic method, while convenient from the standpoint of the teacher, is confusion to the learner.

The introduction is accomplished without any attempt to distinguish between chemical and physical change, so that the thinking pupil is spared the somewhat futile effort usually made by the textbook writer to sharply define the fields of chemistry and physics. Instead of thus trying to get ahead by running around in a circle, the author makes good use of his space in clearly pointing out how necessary and indeed indispensable the physical properties of substances are to the chemist, for our only means of knowing that we have brought about chemical change is by observing that physical properties have changed.

Many new and interesting applications of chemistry are touched upon in the book. Especially interesting are the sections on colloids and the cleansing action of soap solution with explanations of the action, and arguments to show the fallacy in the older explanation,

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How to Be Personally Efficient in Business. 128 pages. 12.5x19 cm. Cloth. 1915. A. W. Shaw Co., Chicago.

Science and mathematics teachers the world over have not taken very kindly to the fact that they should be good business men and women in order to best conduct the business of instruction. A person can best impart his knowledge to others if he has some system and method in his classroom work to aid him in producing the highest efficiency. However well he may understand the subject matter, if he does not make his teaching a matter of business, he will fall short in many particulars. This little book is full from cover to cover of new and up-to-date ideas on the conducting of all kinds of business, and its statements and suggestions will be of the greatest value to all people who make teaching a profession.

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Modes of Research in Genetics, by Raymond Pearl, Maine Agricultural Experiment Station. Pages vii+182. 13x19.5 cm. Paper. 1915. $1.25. The Macmillan Co., New York.

This is a treatment of the subject of genetics which is written in a most interesting manner. It has brought down to date the various investigations on this important theme, and has done it in such a way that the users of the book cannot help but be pleased. The facts and statements made are all authentic, and the method of treatment shows skill and ingenuity and familiarity with the subject. All biologists should possess copies of this valuable treatise. C. H. S.

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Being Well Born, by Michael F. Guyer, University of Wisconsin. Pages xiii+374. 13x19 cm. Cloth. 1915. $1.00 net. The Bobbs-Merrill Co., Indianapolis.

Civilization is becoming more and more cognizant of the fact that she should take an interest in the rights of the young child, and notwithstanding the fact that there are a few people in the world rusty enough to believe that the old-fashioned way of permitting any male and female, no matter how low down in physical development and intellectual caliber they may be, to marry and perpetuate their own kind, the common-sense portion of humanity is rising to the absolute necessity of regulating the quality of the children that are being born into the world. Parents and teachers are continually asking whether such and such characteristics and idiosyncrasies in children are due to heredity, environment or what not. Students of juvenile delinquency and defects in general are everywhere searching for information which will enable them to determine the reasons why certain abnormal conditions in humanity exist. There is no question but what every being has the right to be well born, and every child born at all ought to be brought into the world in an environment which will not work toward his further degradation, but on the other hand will begin at once the development of him into a well-rounded and useful citizen. The work of Dr. Guyer is worthy of much study, consideration, and thought, and should be read by all persons who are endeavoring to put humanity on a higher plane of living. Mechanically the book is well made, with type large, clear and easy to read. C. H. S.

Die Beziehungen der Tiere und Pfanzen zueinander. I. Die Beziehungen der Tiere zueinander, von Dr. K. Kræpelin, mit 64 Abbildungen im Text. 12x18 cm. Cloth. M. 1.25. Druck und Verlag von R. G. Teubner in Leipzig und Berlin.

This book is one of a large series under the general head of *Aus Natur und Geisteswelt.* They are small books of seventy-five to one hundred pages, each a résumé of some topic of interest to scientists. There are two volumes of the relationship of animals and plants to each other—the first as indicated above and the second of the relationship of plants to each other and to animals. The reviewer has also received several other volumes of interest to biologists—one on the microscope and one on the sea previously reviewed in this journal and four volumes on human anatomy. The books are all liberally illustrated and should prove valuable for the teacher of biology who is familiar with the German language. W. W.

Plane and Spherical Trigonometry, by George Wentworth and David Eugene Smith. Pages 230+104. 16x24 cm. $1.35. 1915. Ginn & Co., Boston.

In preparing this work, the authors have selected the material and arranged it with the view of meeting those demands of the schools which they consider legitimate. As far as possible, the practical use of every new feature is set forth before the abstract theory is developed. From the very beginning, a large number of exercises is provided which will give the pupils a real understanding of the angle functions and their use in solving problems. The abundance of practical applications will furnish interesting and profitable work. Such topics as the radian, graphs, applications to higher algebra, and the theory of trigonometric equations have been placed at the end of the book.

The large page has made it possible to arrange the material in a manner pleasing to the eye. All important formulas are made prominent by heavy type, and the work is well arranged in tabular form. The tables are printed in large, clear type, but tables of proportional parts are lacking. This book is well adapted for use in high school. H. E. C.

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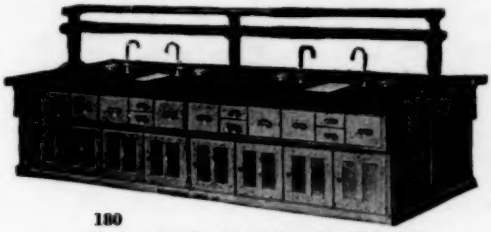

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The Elements of Surveying and Geodesy, by W. C. Popplewell, M. Sc., Lecturer in the University of Manchester, Faculty of Technology. Pages xi+244. 15x23 cm. $2.25. 1915. Longmans, Green & Co., New York.

To present a comprehensive view of the subject of geodesy in its widest sense, giving the information that may lead to a sound knowledge of the fundamental ideas involved, is the purpose of this book. It looks as if the author has done his work well and has presented the principles of surveying as well as many details of actual practice in a clear and interesting manner.

The usual subjects are considered—surveyor's compass, leveling and contouring, rapid surveying, geodetic surveying, geodetic astronomy, hydrographic surveying, underground surveying, and railway curves. Some illustrative examples are given, but no exercises or problems. There is a bibliography covering a page, a brief traverse table, and a four-place table of logarithms. This book should be in the library where students can use it for reference, if it is not used as a textbook. H. E. C.

Diophantine Analysis, by Robert D. Carmichael, Assistant Professor of Mathematics in the University of Illinois. Pages vi+118. 15x23 cm. $1.25. 1915. John Wiley & Sons, Inc., New York.

The present volume, No. 16, of *Mathematical Monographs,* sustains the excellent qualities and serviceableness of this series of monographs. Since the purpose of the book is to serve as an introduction to Diophantine analysis, no attempt is made to include all of the special results. As far as possible a large number of isolated investigations have been systematized and organized into a connected treatment of the subject. The exercises have been selected with a view to afford material for acquiring facility in handling problems in Diophantine analysis; to indicate what special results have already been obtained and what special problems yielded to attack; and to point out some unsolved problems. H. E. C.

Analytic Geometry, by W. A. Wilson, Ph. D., Assistant Professor of Mathematics, and J. I. Tracey, Ph. D., Instructor in Mathematics, Yale University. Pages x+212. 12x18 cm. 1915. D. C. Heath & Co., Boston.

Those parts of analytic geometry which are essential for the study of calculus are presented in this short course. The material is arranged so that less important topics may be omitted, if the fundamental principles and applications of analytic geometry and calculus are to be covered in one year. There seems to be no great departure from the usual treatment of the subject, but it is well adapted to the needs of the pure mathematician, and will no doubt be widely used. H. E. C.

Handbook of Physiology, by W. D. Halliburton, M. D., LL. D., F. R. C. P., F. R. S., Professor of Physiology, King's College, London. Twelfth edition. Pages xvii+964. 15x22 cm. Cloth. 1915. $3.00 net. Published by P. Blakiston's Son & Co., Philadelphia.

The eleventh edition of this book was reviewed in this journal about two years ago. The present volume has been revised to bring it "up to date." The former edition was entirely rewritten and much new material added along the lines of the latest discoveries of research. The book is richly illustrated with nearly six hundred text illustrations, many of which are colored, and three colored plates. The enterprise of the publishers in keeping this standard physiology thoroughly up to date should be highly commended. W. W.